AUGUST, 1952

PETROLEUM REFINER

SPECIALIZED FOR REFINING, NATURAL GASOLINE, AND PETRO-CHEMICAL ENGINEERING, OPERATION AND MANAGEMENT

WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA — GASOLINE ACCESSORIES: Stevelane — Wolverine

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128 Mermaid Avenue, Philadelphia 18, Pa.

the steam trap designed with more production in mind

PETROLEUM REFINER

Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

Volume 31
No. 8

August, 1952

Contents

Are Technical Unions Beneficial To Members? 50
"Yes" say unions, "No" says management—A comparative study.

U. S. Oil Industry Investment Now Approaching $40 Billion Total 52
$3.6 billion addition to domestic facilities in 1952 continues vigorous post-war expansion.

Dehydration of Natural Gas and Light Hydrocarbon Liquids—Part I 65
With the choice of equipment that now exists it is necessary to consider the economic and process factors involved in order to procure the best equipment for the job.
John M. Campbell and Lawton L. Laurence

Wide Range of Feed Stocks Possible With Airlift TCC 71
Yields of motor gasoline on once-through operations range from 37.1% for Slaughter gas oil to 46.0% for Mirando gas oil at same carbon factor.
W. W. Hamilton, S. C. Eastwood, A. E. Petas, E. A. Schraishuhn

Improved Process Polymerizes Olefins for High Quality Gasoline 79
The polymerization of light olefins is aided by a phosphoric acid-on-quartz catalyst. The polymer is a 98 octane gasoline.
G. E. Langlois, J. E. Walkey

How To Do It 84

How To Reduce Phenol in Wastes From Catalytic Processes 88
The method of solvent extraction has been studied extensively to reduce phenol in process accumulator water.
James A. Biehl

Drum Handling Problems Solved With New Layout 91
Here is a complete plan, generously illustrated, showing the modern solution for this frequently difficult technique.
F. W. Shaw, Jr.

Applied Distillation, Part I 95
K. E. Coulter
First of a four-part series on whys and hows of distillation, the ideas being presented from the operating standpoint.

Taking Stock 104
Cecil Smith

Analytical Solution for Crowded Ends of McCabe-Thiele Diagram 105
Robert G. Blick

Around The World With Refining in 1951 108
Daily runs to 722 refineries rise 824,291 barrels.

How Charge Stock Properties Affect Carbon Deposition in Catalytic Cracking 109
Alignment chart yields "coke factor" from four physical properties of the stock.
C. A. Duval and L. S. Holmes

New McElroy-Wilshire Gasoline Plant Dedicated 112

Thermal Insulation for Industrial Requirements, Part VI 113
In this temperature range the design considerations are discussed with new emphasis on properties other than thermal resistance.
Ray Thomas

I Need Help 117
Employe counselor asked for and got the job of listening to workers' troubles and helping them.
Al Reese

DEPARTMENTS

Our Readers' Comments 45
Look Box 47
Refinery and Other Plant Construction 58
How To Do It 84
Taking Stock 104
Refiner Authors and Other Personalities 115
The Month in the Industry 122
Oil Man's Calendar 124
Science and Technology Abstracts 163
Compiled by Drs. E. H. Leslie and H. B. Coats
For More Information on Products Advertised 152
Manufacturer's Literature ..... Insert 152-153
New And Improved Equipment 153
New Catalogs and Equipment Literature in Advertisements 161
Digest of United States Patents Pertaining to Petroleum 179
Compiled by Dr. Heinz Heinemann
Book Reviews 150
About Equipment and Service Suppliers 190
Index to Advertisers 218

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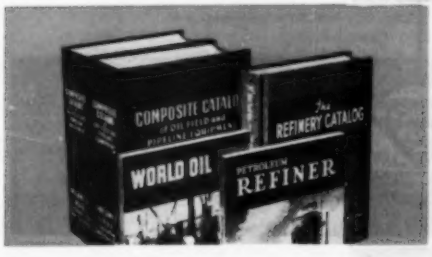

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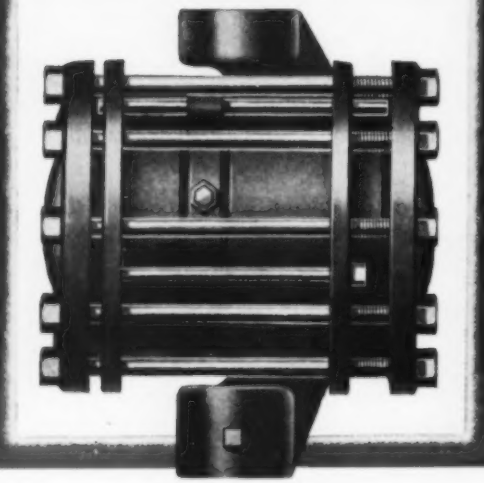

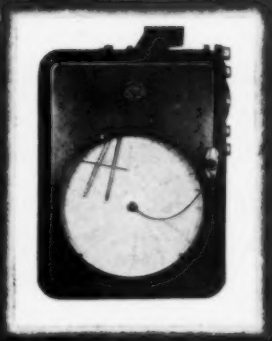

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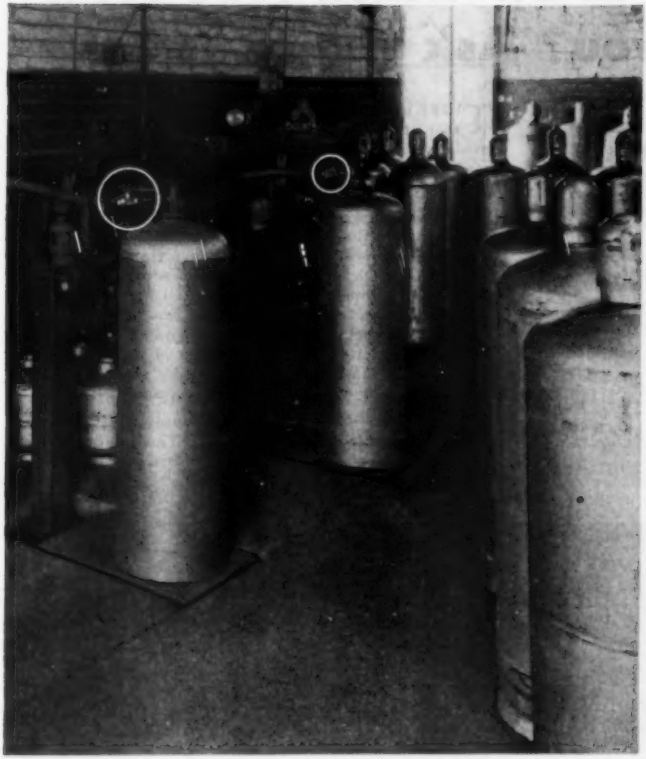

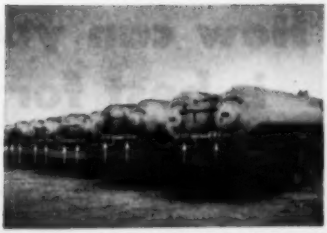

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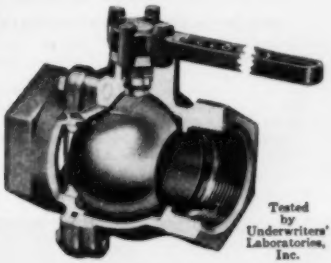

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How can you know which tube steel is best for you? Ask the experts!

This month the Timken Company reports on:

16-13-3 STAINLESS

An austenitic, non-magnetic alloy. For temperatures up to 1500° F., it possesses greater creep and rupture strength than 18-8. Its oxidation resistance and corrosion resistance in hot petroleum products is of the same high magnitude as that of 18-8. It is recommended for use in those high temperature applications in which greater strength is required than can be obtained with 18-8 and where increased resistance to certain acids and salts is desired.

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Carbon	Sicromo 2	Sicromo 5S	18-8 Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
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DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

*Available as seamless tubing on an experimental basis only.
**Not available as seamless tubing.

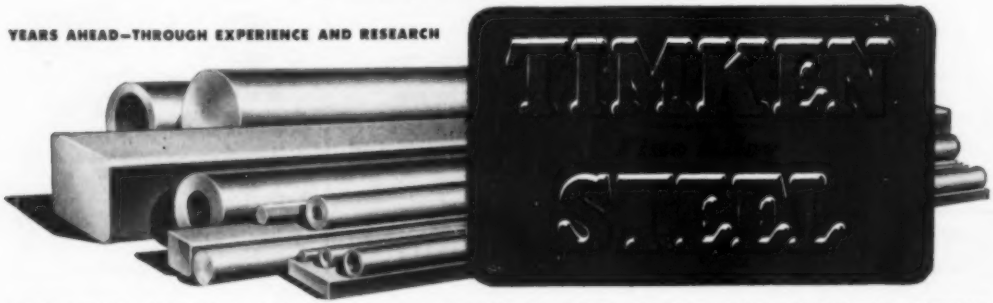
THERE are probably several high temperature steels that are adaptable to your particular heat, pressure, oxidation and corrosion conditions. But there's only *one* steel that's best—the one that will give you maximum tube life per dollar.

To get the one tube steel that gives you the best life/cost ratio, whether it's one of 8 analyses of stainless or one of 16 other analyses, call on the Timken Company's metallurgists. They're recognized authorities on stainless and other high temperature steels. Backed by 25 years' experience in steel development they can help you select the one tube steel that's best for you. And no matter which analysis you select, you can be sure of uniform quality because the Timken Company rigidly controls quality from melt shop through final inspection.

Let Timken "RSQ"—Research, Supply, Quality—solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

Exhaustive research is one reason for Timken's leadership in high temperature steels. Photo shows furnaces in the Timken Company's experimental heat treating laboratory.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



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Also available are stainless castings, valves, pipe fittings, flanges, etc.

Full information on *ESCO* Spuncast pipe is contained in our new catalog "Stainless and High Alloy Products". If you don't already have a copy, we suggest you get one from your nearest *ESCO* representative; or send us the filled-in coupon.

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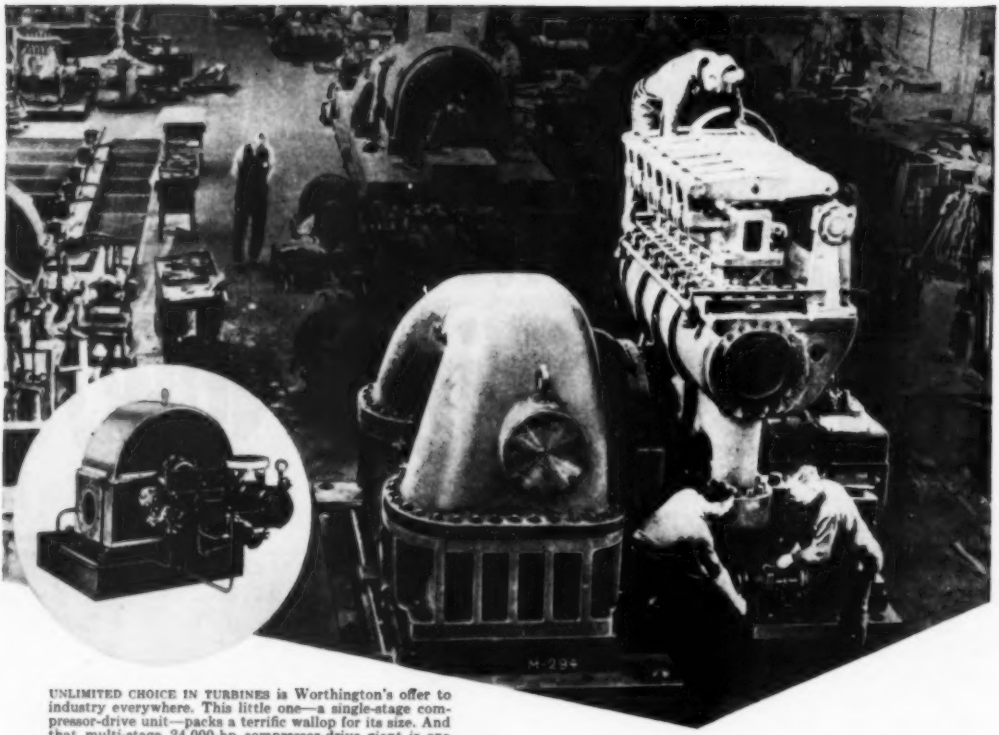


UNLIMITED CHOICE IN TURBINES is Worthington's offer to industry everywhere. This little one—a single-stage compressor-drive unit—packs a terrific wallop for its size. And that multi-stage 24,000-hp compressor-drive giant is one of the largest ever built for this type of service.

Single-stage midgets to multi-stage giants

Whether your turbine requirements call for the biggest or the smallest—straight condensing . . . straight non-condensing . . . extraction . . . mixed pressure extraction . . . low pressure . . . high back pressure . . . for mechanical or generator drive . . . with governors for constant or variable speed—*Worthington has an answer.*

Each Worthington turbine is designed to make the steam do *more* work, so you save power and money throughout its long life.

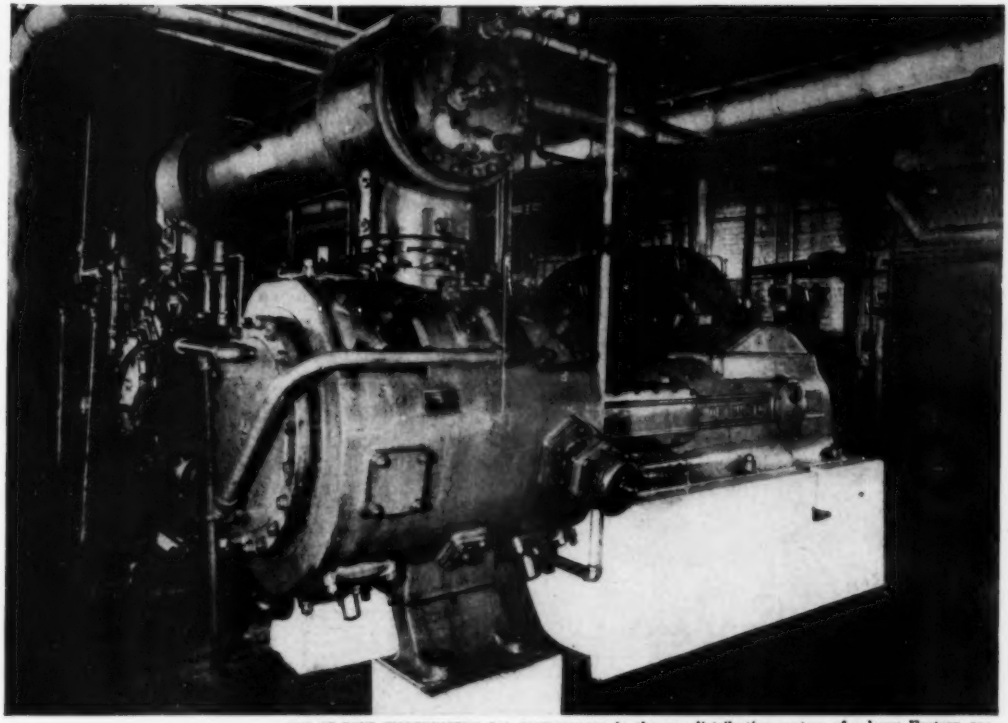
Learn more about Worthington turbines. Get the facts on why *there's more worth in Worthington* by writing to Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.

T-2.2

A GREAT TEAM IN STEAM

WORTHINGTON

Steam Turbines



ONE OF FOUR WORTHINGTON GAS COMPRESSORS in the gas distribution system of a large Eastern gas company. Compressor is positive displacement reciprocating type with capacity of 125,000 standard cu ft of manufactured gas per hour. Maximum discharge pressure is 100 psi. Volume is controlled by Worthington's automatic variable capacity control.

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Accurate control of volume that is always assured with Worthington's automatic variable capacity control — acknowledged most accurate, flexible and simple control obtainable.

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Somewhere in the broad line of Worthington compressors, for air, gas or other "compressables", there is the one right type and size for your job. *Worthington Corporation, Compressor Division, Buffalo, N. Y.*

*Reg. U. S. Pat. Off.

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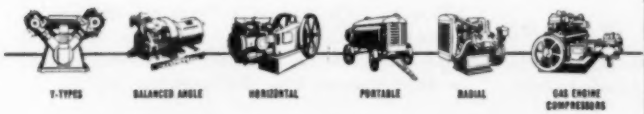

WORTHINGTON

Compressors

No Other Compressor Will Outperform a Worthington

Engineers and process operators can save themselves a lot of time and energy in running tests when they use Speedomax Electronic Indicators for "round-up" checks of temperature and other process conditions.

A flick of the finger connects the desired sensing element to the Indicator . . . the instrument's calibrated drum whirls to the reading . . . the drum stops dead still. The entire operation takes only 4½ seconds for consecutive readings at opposite ends of the scale. Minimum time for close-together points is only a fraction of a second. Logging time depends only on the writing speed of the operator.

126 COUPLES ON ONE INDICATOR

As many as 126 thermocouples may be connected to one Indicator without the use of side panels; with panels the number increases indefinitely. This total of 126 requires toggle-type switches on the Indicator; for rotary and push button switches the totals become 96 and 48. Push buttons are normally supplied with interlocks to assure one-at-a-time operation, but when desired the interlocks can be disconnected so that several switches may be closed simultaneously, causing the instrument to give the average of those points.

As many as 96 Thermohm electrical resistance thermometers may be connected to the Indicator, using either toggle or rotary switches.

Because the Indicator's scale is not a disc, but the rim or "tread" of a drum-like wheel, the calibration lines are non-radial and hence unusually easy to read. The drum's 25-inch scale has an average of 300 divisions . . . can have 500 if necessary. Enclosed slidewire, and thorough shielding against stray fields, are typical details of high-quality construction.

The equipment is described in our Catalog ND46(1). Whether or not you require this information at present, we will be glad to send a copy for reference. Address our nearest office, or 4923 Stenton Ave., Philadelphia 44, Pa.

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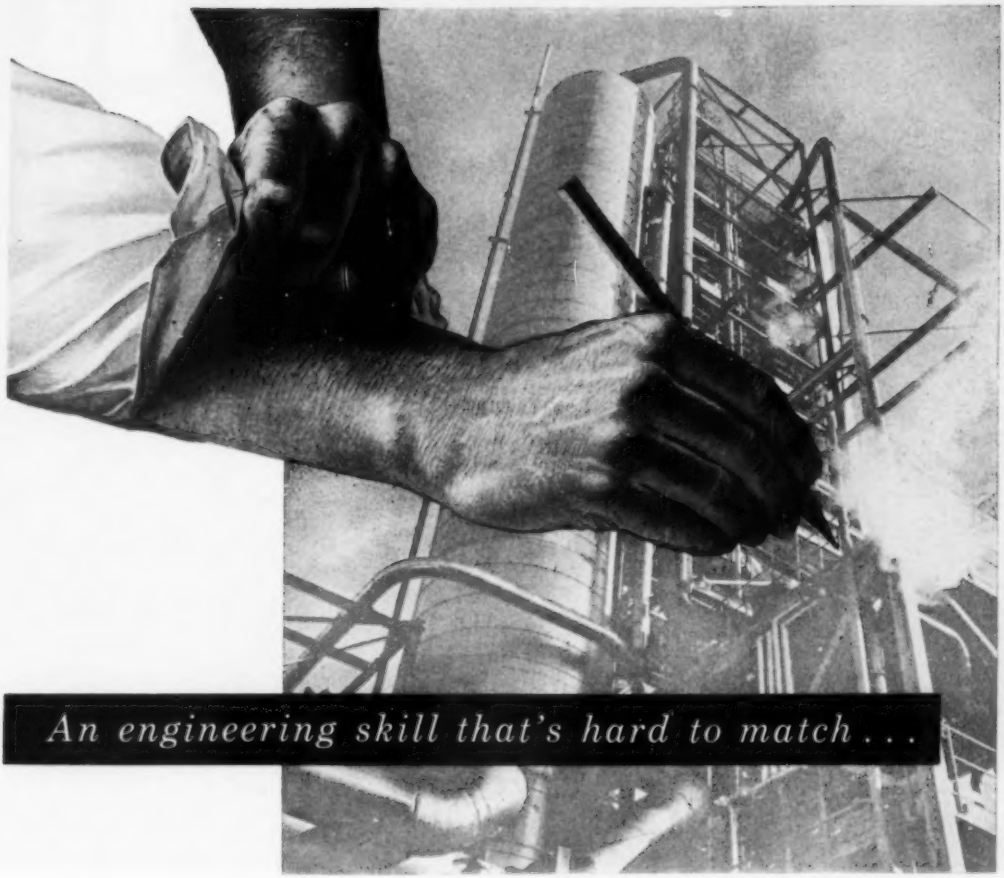

An engineering skill that's hard to match . . .

We mean the skill that's acquired after rolling up sleeves 600 times or more—to design and construct that many petroleum refining, petroleum chemical and chemical plants at sites all over the world.

These plants didn't just happen. Lummus men had ideas, practical imagination, the ability to work, a sharp sense of responsibility, and a company policy which placed no limit upon the physical facilities needed to do the job.

All this is worth its weight in gold—an appraisal which our clients express time and again. We see it as a healthy "atmosphere" in which new processes, new techniques, new equipment and new products are developed to our own high standards, and to the satisfaction and profit of our customers.

So we offer this suggestion: put us down as a group with the depth of chemical engineering talent and the breadth of experience to tackle *your* next engineering and construction project —whatever and wherever it may be. And to do it with a skill that's hard to match.

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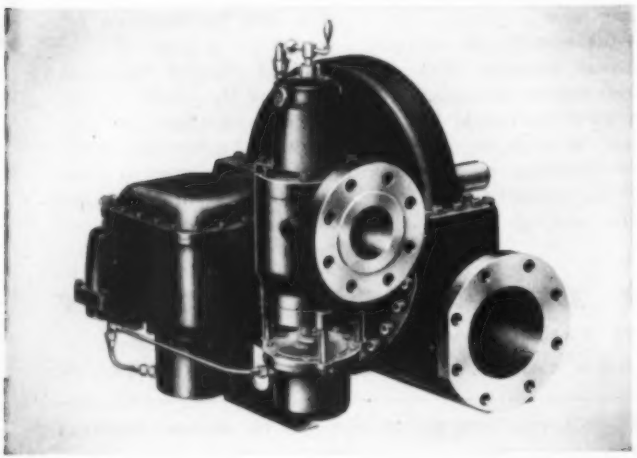
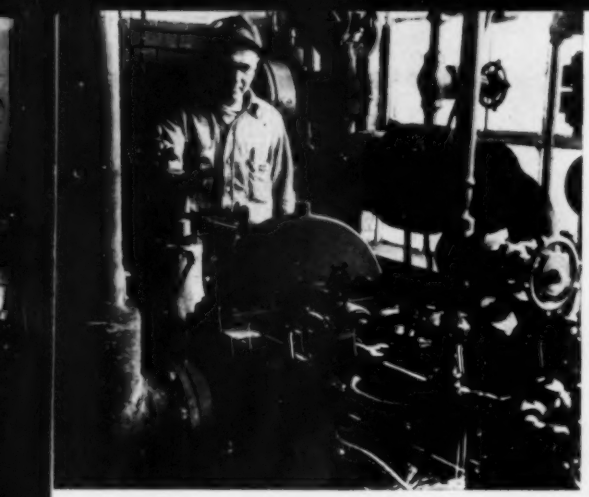
DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

Mr. A. Bourgeois, process foreman at Sohio Refinery, adjusts pump valve. Type DP-20, 125 hp turbine increased by 75% the oil thru-put of this pump which supplies crude oil for the distillation unit.



Type DP MECHANICAL-DRIVE TURBINE

This Type DP turbine is one of General Electric's line of mechanical-drive turbines designed for driving pumps, compressors, blowers, etc. Their sturdy construction and many safety features make them ideal for many petroleum industry applications.



At Sohio's Toledo Refinery, this 15 hp, Type DP-16 turbine with non-sparking enclosed overspeed governor, safely pumps propane in an explosive atmosphere.

Mr. Eugene Ten Eyck and Mr. E. J. Bissonnette of Sohio Refinery discuss stocking of interchangeable parts for the Type DP turbines installed at the Refinery.

Sohio Refinery picks G-E turbine drives to increase oil thru-put

Engineers at Sohio's Toledo Refinery installed two G-E mechanical-drive turbines to help eliminate a bottleneck in refinery operations. A General Electric Type DP-20 turbine increased oil thru-put on one pump at Sohio by 75%, when it replaced older drive equipment. Total daily thru-put of the one pump now equals the former capacity of two pumps.

INSTALLED IN HAZARDOUS AREA

Sohio also installed a G-E Type DP-16 turbine in an explosive atmosphere to pump almost pure propane. The enclosed, non-sparking overspeed governor and the positive trip-throttle valve (which shut off all steam flow in case of overspeed) reduce hazards in this area. The turbine, which operates twenty-four hours per day, has required no maintenance during its first year of service.

VIBRATION REDUCED

Replacement of previous drive equipment with a G-E turbine now assures longer life to other machinery in the area. For G-E turbines with their center-line support and rigid assembly of buckets are now contributing to smooth operation at the refinery.

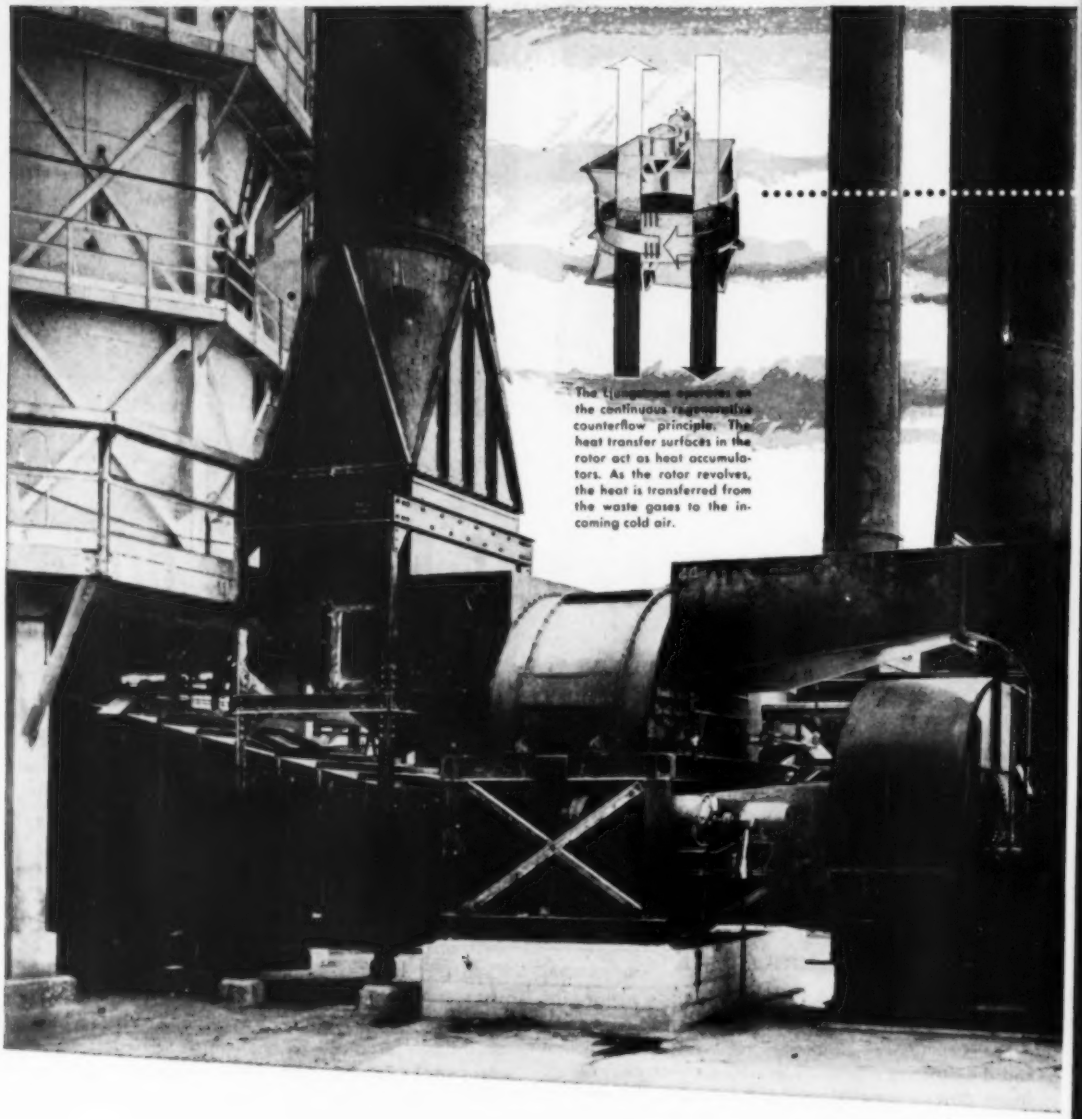
INTERCHANGEABLE PARTS

Use of G-E standard turbines can make stocking of spare parts a simple matter—most replacement parts are interchangeable among various frame sizes of G-E Type DP turbines. Stocking costs are cut, yet parts are available when needed.

This same parts standardization adds to the turbine's flexibility—often the turbine can be adapted to a new plant application with only minor adjustments. Horsepower range can be changed by substituting a different nozzle plate and valve parts.

For more information about the many advantages which these standardized turbines offer the petroleum industry, call in your G-E sales-engineer or write for bulletin GEA-4955A, "A New Standard in Mechanical-drive Turbines." Section 252-56, General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC


The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

Refineries Now Using the Ljungstrom Air Preheater on One or More Process Units . . .

Continental Oil Company
Interocean Oil Company
Le Conselho Nacional de Petroleo Ref.
Lion Oil Company • Ohio Oil Company
Richfield Oil Corporation
Sinclair Refining Company
Socony Vacuum Oil Company
Standard Oil Company of California
Standard Oil Company of New Jersey

The Ljungstrom is no stranger to refineries. For years it has been a standard item for utilizing waste heat from power and process steam boilers. These refiners now use Ljungstrom Air Preheaters on steam boilers . . .

Cit-Con Oil Corporation • Continental Oil Corporation
Esso Standard Oil Company • Humble Oil & Refining Company
Magnolia Petroleum Corporation • Pan-American Refining Company
Phillips Petroleum Company • Shell Oil Company
Standard Oil Company of Indiana
Standard Oil Company of Louisiana
Standard Oil Company of New Jersey • The Pure Oil Company
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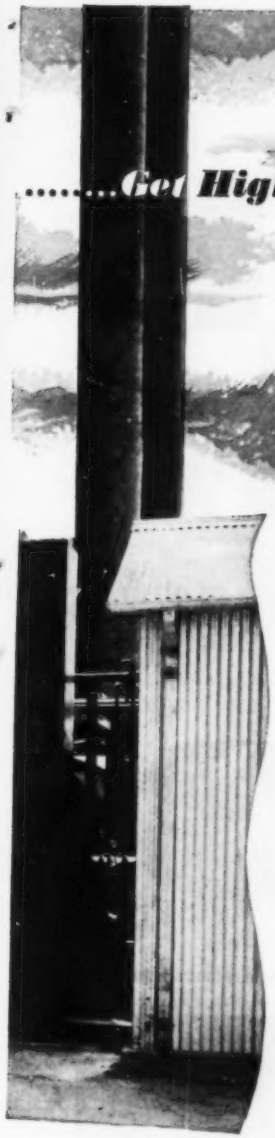

.....Get Higher Throughput . . .

. . . with a Ljungstrom Air Preheater

With the demand for petroleum products at an all-time high, here is a timely suggestion that may point the way to significant production increases in your plant – *without adding a single still.*

A Ljungstrom Air Preheater, properly combined with modern draft and burner equipment, can increase still production as much as 25%. At the same time, plugging is so much reduced that production lost to downtime will be astonishingly low.

The value of the Ljungstrom Air Preheater lies in its ability to recover heat normally lost up the stack, and to return a large portion of it to the furnace zone in the form of preheated combustion air. Fuel requirements are drastically reduced and – where furnace capacity permits – throughput goes up considerably.

Furthermore – the finer temperature control possible leads to a higher average octane rating of the product – often as much as 2 octane points. This alone can mean tens of thousands of dollars a year.

Wherever you are replacing or modernizing equipment that burns fuel – consider the economies you can get with a Ljungstrom. Call or write The Air Preheater Corporation for complete information.

Wherever You Burn Fuel, You Need Ljungstrom

Consider Ljungstrom Air Preheaters for . . .

- Catalytic Cracking
- Coking
- Petrochemical Production
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- Propane Deasphalting
- Reforming
- Solvent Refining
- Thermal Cracking
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THE AIR PREHEATER CORPORATION
60 East 42nd Street, New York 17, N. Y.

Check the three big reasons why it pays to specify Eagle-Picher Insulation:

1.

2.

3.

Eagle-Picher "66" Insulating Cement— All-purpose, rust-inhibitive, super-adhesive insulating cement. Great coverage, extreme thermal efficiency with "Springy Ball" pellets which won't collapse after application. Easy trowel application over all kinds of surfaces. Efficient up to 1800 F... reclaimable where temperatures do not exceed 1200 F.

THE EAGLE-PICHER

Cost-cutting insulations of top thermal efficiency

Insulating Cements

Fireproofing Cements

Supertemp Block

Blankets

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Stalastic

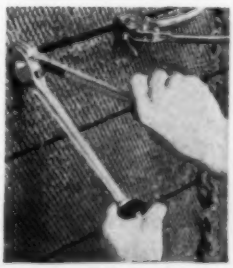
Dependable contractors, trained to strict factory standards

You can count on Eagle-Picher authorized contractors for uniformly high caliber service. Their qualifications provide assurance of a good job *every time* . . . efficient application of the Eagle-Picher insulation that best fits your needs.

Fast delivery from strategically located distribution points

The Eagle-Picher insulation line is stocked by distributors and authorized contractors coast to coast. The one nearest you will be happy to recommend insulating materials that give your equipment highest thermal efficiency . . . reduce fuel costs . . . help provide precise temperature control.

Eagle-Picher Supertemp Blocks—
A real insulating block—not a refractory! Unequalled for insulating quality. Weighs approximately 22-24 lbs. per cu. ft. Cuts easily with knife or saw . . . fits snugly over contoured surfaces. Monolithic structure . . . high refractory value. Withstands temperatures up to 1700 F. All standard sizes, from 3″ x 18″ to 12″ x 36″. . . in thicknesses from 1″ to 4″.



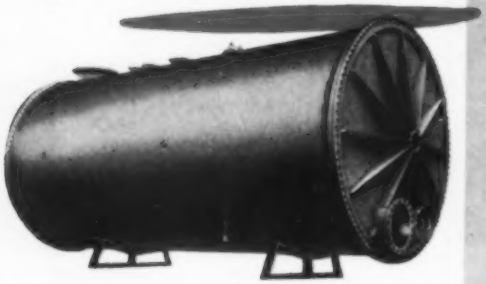
Eagle-Picher Mineral Wool Blankets—
Made under factory supervision, these blankets fill your needs for fast, convenient insulating of flat or curved surfaces on larger types of heated equipment. The wool is felted and secured by flexible metal fabric . . . possesses outstanding physical and chemical stability for maximum resistance to water, steam, corrosive fumes and vibration.

COMPANY EAGLE EP PICHER

General offices: Cincinnati (1), Ohio
Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

Outstanding — IN Sulphur Recovery WASTE HEAT APPLICATION!

Titusville



Boiler above has 3500 sq. ft. heating surface. Design pressure 150 PSIG. Combustion area 6 PSIG. Process and combustion gases as fired: 22,000 lbs. per hour. Combustion gas temp. 2930°F.—exit temp. 530°F. Diameter of unit 114". Length over nozzles 24'3¼".

USED BY SUCH COMPANIES AS

Phillips Chemical Co.	Sinclair Refining Company
Gulf Oil Corporation	Consolidated Chemical Industries
Shell Chemical Corp.	Hancock Chemical Company

—and others

WASTE HEAT BOILERS

TITUSVILLE Waste Heat Boilers have been used with marked success for years in connection with sulphur recovery, and are in service or process of installation for most of the major oil producers and refiners in America.

Of basic Scotch Marine design, these units are fitted with special front and rear combustion chambers, and are sealed against pressure in the combustion area. The delivery picture is good: your order can be shipped within a comparatively short time, utilizing units in stock—in fabrication, or built from stock material.

THE TITUSVILLE IRON WORKS COMPANY

Division of Struthers Wells Corporation

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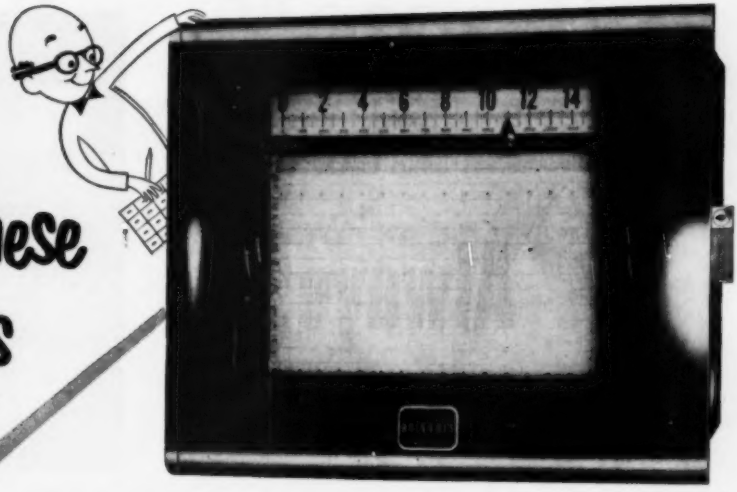
TITUSVILLE IRON WORKS CO TITUSVILLE, PA.

Struthers Wells



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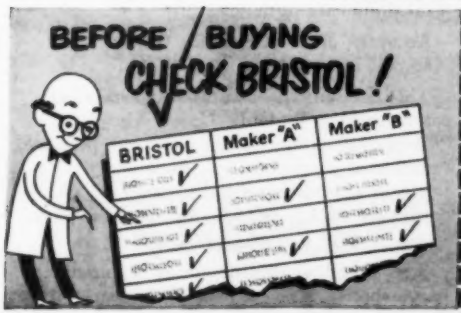
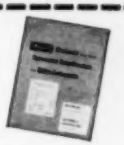


THE BRISTOL COMPANY
111 Bristol Road
Waterbury 20, Conn.

Please send catalog giving details of Dynamaster performance to:



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This combination assures you maximum service from Republic Upson Alloy Steel Studs under severe corrosion, pressure, and heat conditions . . . these precision studs fit-up tight, stay tight; yet turn-off readily for equipment maintenance.

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Bolt and Nut Division • **CLEVELAND 13, OHIO**
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Your *Best* Motor Buy

for Explosion Danger Areas

Here's Why

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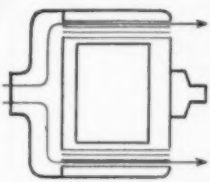
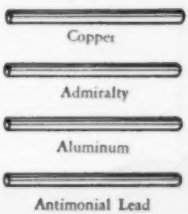


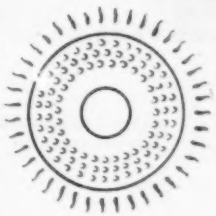
Air-to-air heat exchanger has straight, smooth tubes with no pockets to collect dirt or moisture. Velocity of cooling air through tubes keeps surfaces swept clean. If sticky dirt piles up, tubes can be cleaned quickly with long handled brush.

Choice of Tube Materials



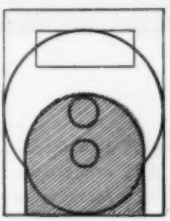
Allis-Chalmers tube-type motors can be built for service in corrosive atmospheres. Tubes may be made of a variety of materials. Motors will carry Underwriters' Label for Class I Group D or Class II Group F or Class II Group G.

Uniform Cooling



Tubes for carrying cooling air are distributed uniformly around the perimeter of the stator and along its full length. Result: heat travels over a short path and the interior is uniformly cooled.

Compact



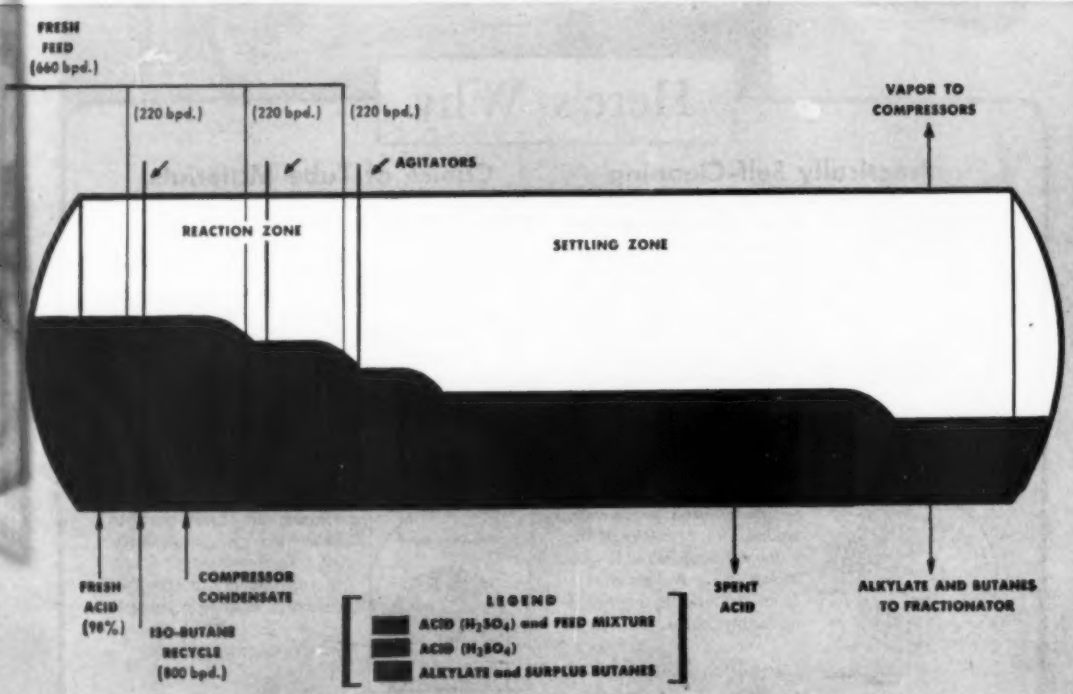
Allis-Chalmers tube-type motors are little or no larger than open motors of the same rating. Internal compartmentation divides motor into two chambers, keeping pressure at a lower level should an internal explosion occur.

Get Complete Information Now — Ask your Allis-Chalmers district office representative about tube-type explosion-proof motors in sizes up to 2000 hp with Underwriters' Labels to 800 hp. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, and ask for Bulletin 51B7149.

A-3768

ALLIS-CHALMERS

This NEW Kellogg-cascade reactor initial cost



How New Reactor Maintains 9-to-1 Isobutane-Butylene Ratio

Assume, as a simplified case, that fresh feed is charged to the reactor shown here at 660 barrels per day. This feed, comprising a mixture of approximately 300 barrels of butylene and 360 barrels of isobutane, is divided into three equal 220 BPD portions, each of which is introduced into one of the three reaction sections.

To increase the amount of isobutane at the points of reaction, a recycle stream of isobutane from the unit's main fractionator is fed in at the bottom of the first section. This recycle must be at a rate of 800 BPD to provide the desired isobutane-butylene ratio.

Adding up the total amount of isobutane in the first reaction section, we find there are 920 barrels to 100 barrels of olefin. Since only about 110 barrels of the isobutane reacts with the total olefin present, about 810 barrels of excess isobutane are carried over into the second section where the cycle starts over again.

Thus, while the total amount of olefin charged each day to this reactor is 300 barrels and the total amount of isobutane is 1160 barrels (a ratio of about four-to-one), the actual ratio at all reaction points is better than *nine-to-one*.

designed brings lower to sulphuric acid Alkylation...

SULPHURIC ACID alkylation has long been recognized as a vital process in the production of high octane avgas and a valuable tool for upgrading a refinery's motor gasoline pool.

Now several Kellogg design innovations have been incorporated in this process which reduce the initial investment required, as well as the daily operating costs, for the production of a given quality and quantity of alkylate.

The most important improvements have been made in the reactor itself. With the new Kellogg cascade reactor, a highly desirable nine-to-one ratio of isobutane to butylene is maintained *in the reaction zones*—although the overall isobutane *feed* to the reactor is less than four-to-one. While increasing the yield and improving the quality of alkylate, this new design also materially reduces the number of pumps and permits use of smaller vessels than would otherwise be required to attain a high isobutane-butylene ratio.

In addition, the cascade flow of acid and fresh feed in successive stages radically improves the economics of acid consumption. When feeding 98% sulphuric acid to the new Kellogg units, the acid concentration can be maintained at an efficient average of 91.5% in all reaction zones, while the withdrawal concentration is kept at a low 88%.

Add to these advantages the low horsepower requirements of propeller-type agitation and the savings inherent in auto refrigeration cooling . . . and it is evident why many refiners are exploring the possibilities of modern sulphuric acid alkylation.

New Kellogg-Designed Units

UNITS OPERATING
- In the Midwest—2500 BPD unit
- In the Southwest—1000 BPD unit
- On the Atlantic Seaboard—2200 BPD unit

UNITS UNDER CONSTRUCTION
- In Texas—1200 BPD unit
- In South America—1600 BPD unit

UNITS IN ENGINEERING
- On the Atlantic Seaboard—3500 BPD unit
- In Texas—1200 BPD unit

For further information, yield and inspection data, etc. write

THE M. W. KELLOGG COMPANY

(SUBSIDIARY OF PULLMAN INCORPORATED)

for fifty one years an integral part of petroleum refining progress!

KELLOGG

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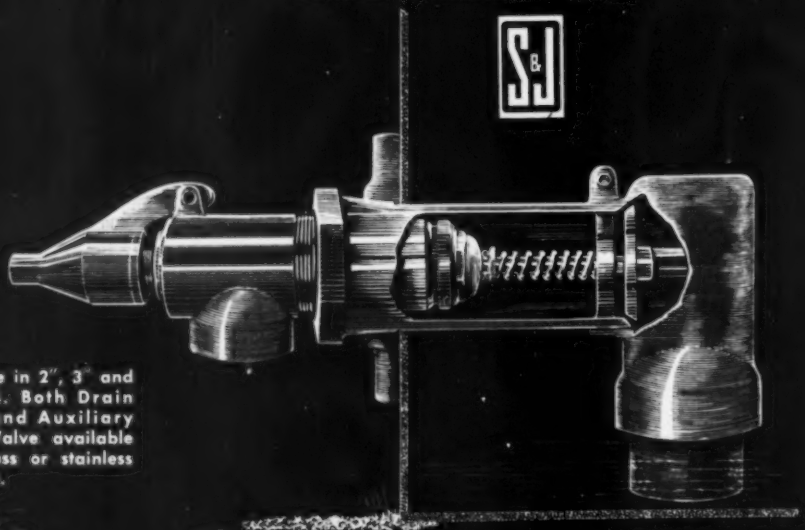
Operation *Simplified*

The S&J Anti-Freeze Drain Valve, illustrated in the drawing below, was designed to draw water off the bottoms of petroleum storage tanks, and remain operable during sub-freezing weather conditions. This is accomplished by constructing the internal parts of the valve to be self draining. If water will not remain inside the valve body, obviously the valve cannot freeze up and become inoperative.

In the illustration of Model ST-2001-AV shown below, the Anti-Freeze Drain Valve is screwed into an auxiliary shut-off adapter sleeve, which permits removal of the valve from the tank without having to drain its contents. With the valve functioning, manual operation opens the auxiliary to give full flow characteristics; closed, the auxiliary is also self draining.



Available in 2", 3" and 4" sizes. Both Drain Valve and Auxiliary Safety Valve available with brass or stainless steel trim.

Shand and Jurs Co. 917 CARLETON STREET · BERKELEY · CALIFORNIA

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Now. . 2 plants to better serve you
in our 20th year in Houston . . . . . .

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You'll save time and trouble on H.P. VESSEL GASKETS

...when J-M Goetze gasket specialists make them for you

When you need gaskets such as those above, which were made for pressure vessel service over 5000 psi, consider this. It takes less time and trouble to turn the job over to J-M Goetze —an organization that has specialized in gasket design and manufacture for 67 years. And it usually costs less in the long run.

Goetze engineers can select the right style for maximum sealing efficiency. They know the correct metals and other factors required for efficient, long-lasting gaskets.

Goetze Gaskets are made exactly to the last detail of your specifications and conditions. They are made to craftsmen's perfection . . . with modern machine tools, some of which were specially designed by Goetze for gasket manufacture.

If you need gaskets for high pressure vessels or similar applications, send us a drawing or template for quotation. Or write for further information to Johns-Manville, Box 60, New York 16, New York.

Johns-Manville *Goetze* GASKETS

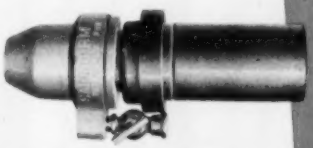
THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE

The amazing, new SANSTORM WETBLAST NOZZLE

. . . attaches to any ordinary faucet . . . to any compressor. This attachment will simplify your wetblasting operations to the point where you'll wonder how you ever got along without it.

You need no separate water tank with the amazing new SANSTORM wetblast nozzle. Use it with any equipment you have.

SANSTORM wetblast nozzle is small, compact, works with any compressor, any type water outlet, and it needs no exact water pressure to operate. This light cast aluminum nozzle won't rust, either.



Complete unit consists of Sanstorm WH2 Wetblast lead assembly, Sanstorm AB20 Quick detachable nozzle holder, and Sanstorm ABN tungsten carbide lined long life blasting nozzle.

For further information call or write:

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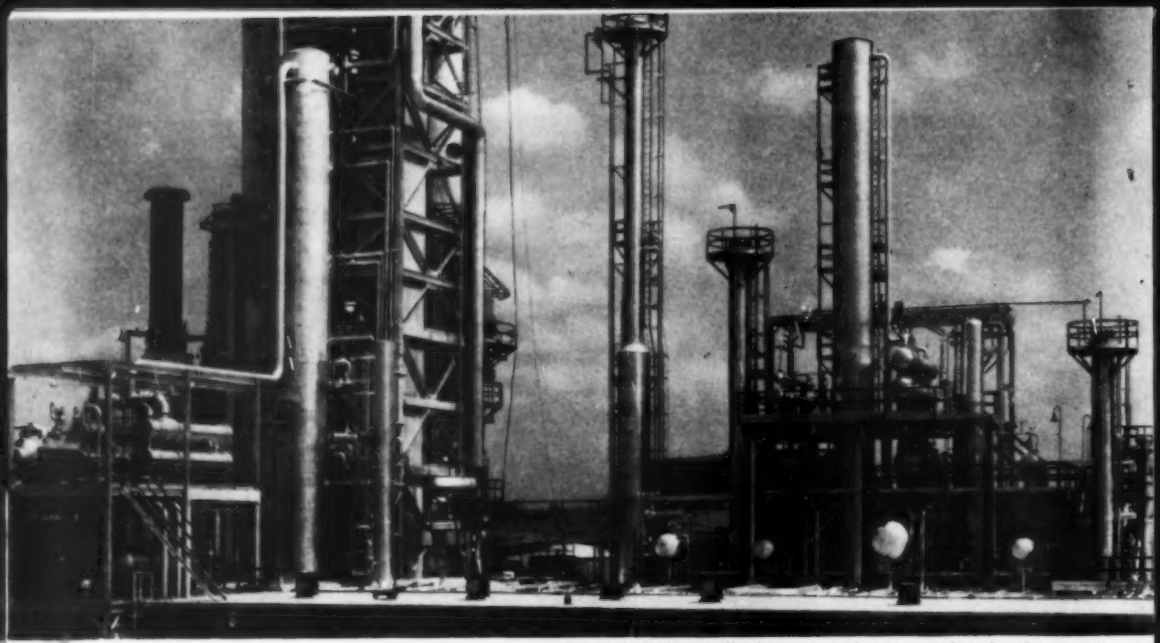
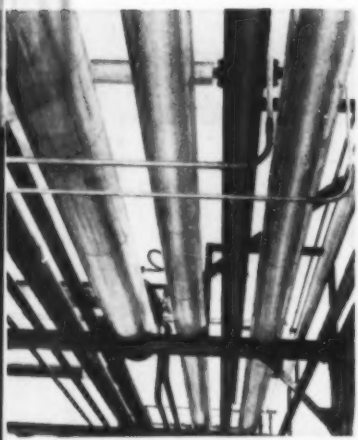


Refineries cut maintenance on insulated lines by switch to new low-cost aluminum jacketing

"It cut jacketing application costs, and we expect it to last for years," report engineers at refineries everywhere after testing Childers Aluminum Jacketing on their insulated lines. This new Oklahoma refinery used Childers 100% — on towers and vessels (in heavy weight) as well as on lines. It is flexible and easy to put on, and this 35 alloy aluminum is tough and weather-resistant, even in corrosive industrial atmospheres. This is the first and only jacketing especially engineered for process plants and power installations.

At least 567 processing plants have installed and tested this new Childers Aluminum Weatherproof Jacketing during the last three years. You can examine its advantages for your plant by writing for a free sample. Address Childers Manufacturing Co., Dept. PR-11, 3620 West 11th Street, Houston 8, Texas.



These lines are insured for years against wear and weather. They'll never need painting because Childers Jacketing gives them all the advantages of appearance and long life that come only with weather-resistant aluminum. Yet this specially engineered jacketing costs far less than would heavy aluminum sheets.

As shown here, Childers Jacketing can be attached with no more tools than a pliers and a wooden wedge. No expensive shop work or pre-forming are necessary. Several methods of attaching are available, but aluminum bands shown here are probably best and cheapest. Because this jacketing is so easy to handle and so simple to attach, it cuts installation costs way down.

This is how the flexible, easy-to-handle Childers Jacketing arrives at the job site. It is in convenient rolls 4 feet wide and 100 feet long—just right for one man to handle—and is available either with or without a moisture barrier attached on the back of the .006" aluminum "skin". It can be cut to proper lengths using any flat table and a straight-edge.

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Under CMP regulations, Childers is a Class B product, the use of which is not restricted.

This 7-Letter Word Tells the Story

• There are many descriptive words and phrases we might use to prove the effectiveness of Zallea Stainless Steel Expansion Joints as the ideal medium to absorb thermal expansion and contraction in pipelines. But no single word has more convincing meaning . . . more significance than the simple 7-letter word . . . "*reorder.*"

Over the past 23 years, thousands of industrial organizations have expressed their confidence in our products by reordering not once, *but time and time again!*

Here's a sample of the record:

Company	Number of Orders Placed*	Since
American Viscose Corp.	79	1940
Bethlehem Steel Corp.	51	1938
Carbide & Carbon Chemical Co.	93	1936
Consolidated Edison Co.	115	1933
Dravo Corporation	53	1939
E. I. du Pont de Nemours & Co., (Inc.)	308	1934
Ebasco Services	46	1934
Hercules Powder Co.	133	1937
Koppers Co., Inc.	165	1942
Nordberg Mfg. Co.	174	1942
Sun Oil Co.	60	1938
Texas Co.	261	1938

**Including as many as 485 expansion joints in a single order!*

This acceptance is your assurance of the dependable, economical performance you'll receive when you, too, order and *reorder* Zallea Stainless Steel Expansion Joints. Why not write us *today*? Zallea Brothers, 809 Locust Street, Wilmington 99, Del.

Catalog 47 and Bulletin 351 describe the complete line of Zallea Expansion Joints and Flexible Connectors. Write for copies today.

Zallea
EXPANSION JOINTS

this Plus Value in B&W process equipment

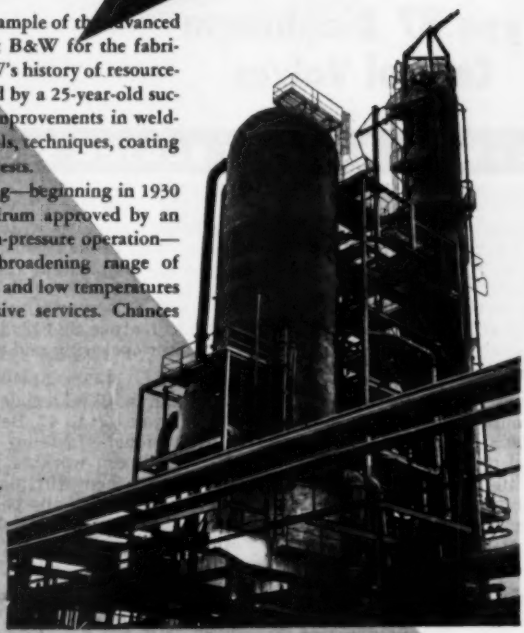
Another Example of B&W Research, Engineering & Facilities

S-4097

PAYS DIVIDENDS HERE

Illustrated at left is a typical example of the advanced welding practices employed at B&W for the fabrication of pressure vessels. B&W's history of resourceful engineering is distinguished by a 25-year-old succession of developments and improvements in welding machines, automatic controls, techniques, coating of electrodes, inspections, and tests.

B&W's leadership in welding—beginning in 1930 with the first welded boiler drum approved by an engineering authority for high-pressure operation—is being applied to an ever-broadening range of quality-welded vessels for high and low temperatures and pressures, and for corrosive services. Chances are B&W has the economical solution to your process equipment problems. The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.



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TAKE NO CHANCES WITH SLIGHT LEAKAGE

APPLICATION: Where even slight leakage of a flowing medium might become obnoxious, dangerous or excessively expensive.

Specify

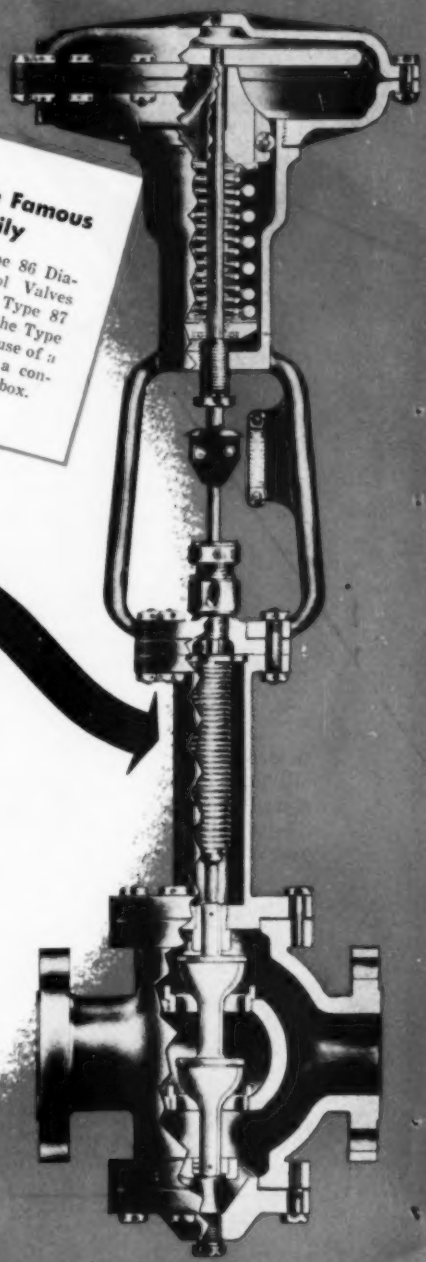
BS&B CLIMAX

Type 87 Diaphragm Control Valves

From The Famous Family

of Climax Type 86 Diaphragm Control Valves . . . the NEW Type 87 . . . identical to the Type 86 except for the use of a bellows seal plus a conventional stuffing box.

. . . with bellows sealed stem



Constantly striving to improve an already satisfactory item—that's part of the BS&B policy, part of our way of doing business. For example, take BS&B Climax Type 86 Diaphragm Control Valves of which the Type 87 is a family member. All Climax Type 87 valve bodies are designed to conform to I. S. A. tentative face-to-face standards. New designs continue to feature BS&B's interchangeability-of-parts advantage for greater operating and maintenance economy.

Type 87 is manufactured for all services and in all materials that are contemplated by Type 86 and in sizes from ½" to 6". Bellows can be supplied in bronze, stainless steel, Monel, Hastelloy "B", Nickel or other special alloys suitable. Maximum working pressure 400 lbs. cwp. The conventional teflon packed stuffing box is installed at the point the valve stem passes out of the bellows casing to forestall any appreciable loss of flowing medium in case of bellows failure.

Ask your BS&B MAN...33 Branches...13 Sales Offices...Ask for New Climax Catalog Section 105—recently revised—or write Black, Sivalls & Bryson, a leader for 60 years in oil and gas producing and refining equipment...out in front with controls and equipment for the processing industries.

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Climax Controls Division, Dept. 4-F2

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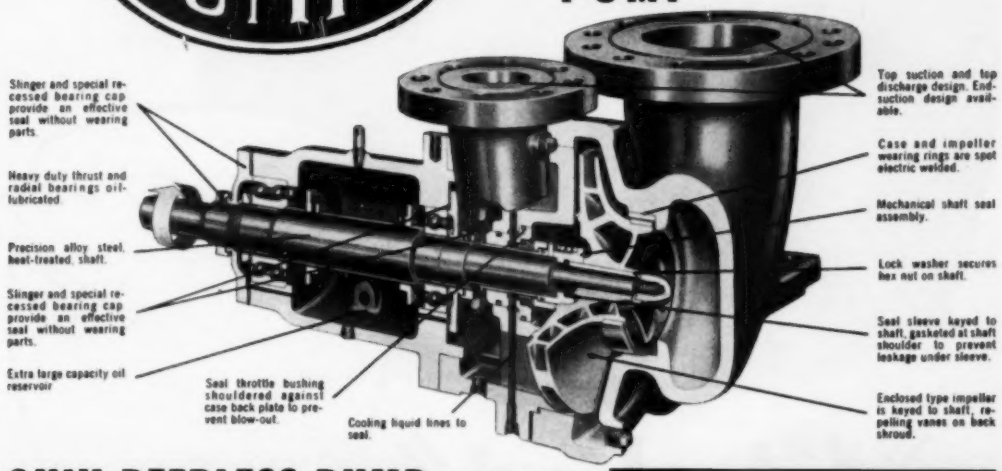
PEERLESS PUMPS

Type PRS

REFINERY AND CHEMICAL PROCESS PUMP


Slinger and special recessed bearing cap provide an effective seal without wearing parts.
Heavy duty thrust and radial bearings oil-lubricated.
Precision alloy steel, heat-treated, shaft.
Slinger and special recessed bearing cap provide an effective seal without wearing parts.
Extra large capacity oil reservoir
Seal throttle bushing shouldered against case back plate to prevent blow-out.
Cooling liquid lines to seal.
Top suction and top discharge design. End-suction design available.
Case and impeller wearing rings are spot electric welded.
Mechanical shaft seal assembly.
Lock washer secures hex nut on shaft.
Seal sleeve keyed to shaft, gasketed at shaft shoulder to prevent leakage under sleeve.
Enclosed type impeller is keyed to shaft, repelling vanes on back shroud.

ONLY PEERLESS PUMP OFFERS THIS HEAVY DUTY PROCESS PUMP—

***designed with and for a* MECHANICAL SHAFT SEAL**

SHAFT SEAL DESIGN PERMITS USE OF SHORT SHAFT WHICH MEANS LESS DEFLECTION, GREATER RIGIDITY, MINIMUM RUN-OUT, LESS WEAR IN BEARINGS, WEAR RINGS, SEAL AND MOVING PARTS... A first from Peerless! This heavy duty, center-line-mount pump designed with and for a mechanical shaft seal also has many other advantages including: **GREATER SAFETY:** Throttle bushing is shouldered against case back plate from suction side; cannot blow out even under maximum operating pressure. **GREATER ECONOMY:** No premium is charged in first cost for the mechanical shaft seal construction of the Type PRS pump. Lower maintenance costs will be effected throughout its longer life. **AVAILABILITY:** Peerless Type PRS pumps are available for quick assembly and shipment from Peerless' Los Angeles stock in several sizes.

USE IT FOR PUMPING

All petroleum hydrocarbons, process liquids, hot oil, water, at elevated temperatures and pressures. Liquid end case can be furnished in material suitable to the service.

HERE ARE ITS CHARACTERISTICS

Capacities:	up to 1000 gpm
Operating Heads:	up to 625 feet
Case Pressures:	up to 400 psig
Temperatures:	up to 250° F
Drives:	horizontal electric motor is standard; other types available as required.

WRITE FOR INFORMATION

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
301 West Avenue 26
Los Angeles 31, California

Please send us information on the Type PRS pump.

Name_____

Company_____

Street_____

City_____ State_____

PET. REF.

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
Address inquiries to Factories at:
Los Angeles 31, California, and Indianapolis 8, Indiana
Offices: New York, Atlanta, Chicago, St. Louis, Phoenix, Fresno, Los Angeles, Dallas, Plainview and Lubbock, Texas; Tulsa, Albuquerque, N. M.
Distributors in Principal Cities; Consult your Telephone Directory.

PEERLESS PUMPS fmc

Layne's new all color and sound motion picture "DEEP WATER" brings to the screen a dramatic story of how Layne builds the world's finest water supply wells and pumps. For details on booking this picture for a showing without cost or obligation address Public Relations, Layne & Bowler, Inc., General Offices, Memphis 8, Tennessee.

"Styled"

for non-overloading high efficiency

All Layne Impellers—the business end of a pump—are "styled" for the very maximum in high efficiency. Free from the overloading fault, these impellers are capable of producing tremendous quantities of water at unmatched low cost. All are hand finished inside and out to provide utmost accuracy.

If you are in need of a vertical turbine pump to produce water from a well, lake, reservoir or river—or as a pressure booster for a water main, write for a catalog on Layne Pumps. No obligation.

But whether you are checking impellers, pump bowls, shafting, bearings or other parts of a water supply unit, it is important to remember that Layne built wells and pumps are rated as the world's very finest. Everything about these units, are engineered for long years of top flight efficiency. Satisfactory service, extra heavy production and absolute freedom from structural weakness.

For further information about well installation services, sizes and types of pumps or a complete water supply contract, address

LAYNE & BOWLER, INC.
General Offices, Memphis 8, Tenn.

Layne
WATER WELLS
VERTICAL TURBINE PUMPS
WATER TREATMENT

For example . . .

Back in 1925, Ethyl engineers developed a vacuum system that the industry now uses for the mixing of antiknock fluid with gasoline. The heart of the system is an eductor, and the main advantage of the system is that at no time is fluid under pressure. If a leak should develop, air leaks in—not fluid out—an important safety feature.

Over the years, we've improved piping and valve manifolding arrangements, made improvements in mixing techniques, but the basic principle of a completely closed system hasn't been changed. This worried us, because we felt that, with the years and the many technical advances, there

(*Continued on next page*)

ETHYL
ETHYL CORPORATION

Never leave well enough alone

(*Continued from preceding page*)

must be a better way to do almost anything. Our research engineers experimented with all sorts of ideas, but couldn't seem to find anything that would do the job any better.

To assure ourselves that we hadn't overlooked anything, we called for an outside opinion. Arthur D. Little, Inc., of Cambridge, Mass., was brought into the picture. They put their best brains on the job. Well—to make a long story short—they could find no way to improve on the eductor system.

The Ethyl mixing system is one of the few things, if not the only one, that we haven't been able to greatly improve over the years. We still hope to find something better. The point is that we are going to keep on trying, because we "never leave well enough alone."

ETHYL CORPORATION

NEW YORK 17, NEW YORK

Ethyl service is backed by 29 years of antiknock experience

RESEARCH

SALES HELPS

FARM SERVICE

ROAD TESTING

SAFETY SERVICE

GASOLINE TESTING

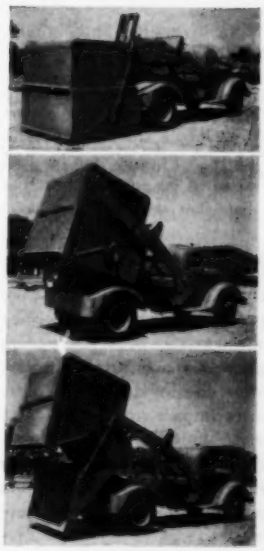
One DEMPSTER-DUMPSTER Serves Scores of Containers . . All Designs . . . All Sizes . .

Handling Materials of Almost Every Description at the Lowest Possible Cost!

One Dempster-Dumpster mounted on one of your trucks serves any required number of big detachable Dempster-Dumpster Containers spotted at convenient materials accumulation points inside and outside your buildings. The capacity of these containers range up to four times greater than the average dump truck body. They are built in a wide variety of designs best suited to the materials handled—be they solid, liquid or dust . . . trash or rubbish . . . bulky light or heavy. The truck-mounted Dempster-Dumpster, with only one man, the driver, picks up one pre-loaded container after another, hauls it to destination where materials are dumped or load set down intact. The Dempster-Dumpster may handle raw materials on one haul, liquids on another, trash and rubbish on another, etc. It's like having one truck with 15, 25, 65 or 100 different bodies.

This is the *Dempster-Dumpster System*—the modern method of bulk materials handling. It is saving thousands of dollars annually for hundreds of plants in every type of industry because it: Eliminates 3 to 5 conventional trucks and crews—reducing cost of truck equipment and operation accordingly. . . Eliminates standing idle time of trucks and crews. . . Eliminates re-handling of materials. . . Increases efficiency, sanitation and good housekeeping.

The *Dempster-Dumpster System* is, without question, the most efficient method of materials handling by truck ever devised! More efficient and lower cost materials handling in your plant may be simply a matter of getting the minds of your engineers and ours together. Write us now. The *Dempster-Dumpster System* is manufactured exclusively by Dempster Brothers, Inc.



WHEN A CONTAINER is full, the Dempster-Dumpster picks it up, hauls it to destination and dumps the materials or sets the load down intact. These three simple operations, shown above, are hydraulically controlled by driver in truck cab.

DEMPSTER BROTHERS, 582 Dempster Bldg., Knoxville 17, Tennessee

A 500-liter Dewar Flask, made of Monel®, used for transporting liquefied gases. Hofman Laboratories, Inc., of Newark, N. J., chose Monel for this service because it has the necessary strength and toughness at −330°F., and because Monel takes a mirror finish required for very high insulating vacuum.

What happens when temperatures DROP?

Many materials behave strangely at sub-zero temperatures . . . but Inco Nickel Alloys often have *improved* characteristics . . .

When the mercury freezes solid . . . and the temperature keeps on falling, common objects develop startling traits.

A rubber ball shatters under a hammer blow. An orange can be used to drive a nail. A garden hose becomes a rigid bar that will support your weight.

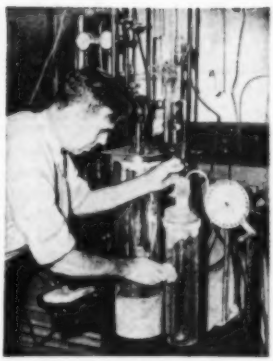
To the designer of low-temperature equipment, these unfamiliar antics pose serious problems. Many metals become excessively brittle . . . often to the point of being useless as structural materials. For example, an alloy steel, with a room temperature impact strength of 119.8 foot-pounds, showed a drop in impact strength to only 6.4 foot-pounds at the temperature of liquid nitrogen. Other carbon and low alloy steels show similar tendencies.

The key that has unlocked many such problems is *nickel*. Used as an alloying element in steels, nickel decreases low-temperature embrittlement. The Inco Nickel Alloys, Monel, Nickel and Inconel, actually *increase* in strength when temperatures drop, and without appreciable change in ductility.

In addition to very superior low-temperature characteristics, the Inco Nickel Alloys offer several other important engineering advantages . . . excellent resistance to the corrosive action of a wide variety of chemicals, workability and weldability, good resistance to both stress- and vibration-fatigue.

Among the many low-temperature applications, where Inco Nickel Alloys can prove highly successful, are: producing, handling and storing of liquefied gases; laboratory research, low temperature treatment of metals.

Right now nickel and nickel alloys are on extended delivery because so much is needed for defense. Therefore, it's wise to anticipate your needs and place your orders, with necessary N. P. A. ratings, well in advance. And for helpful advice on metal problems, feel free to consult Inco's Technical Service Section. They will be glad to help you — without cost or obligation, of course.



Helium liquefier at the National Bureau of Standards, used to study the behavior of the gas at −455.75°F. — less than 4 degrees above absolute zero. Heart of the apparatus is a thick-walled Monel chamber in which helium is cooled under pressure, preparatory to expansion and liquefaction.

EMBLEM OF SERVICE

NICKEL INCO ALLOYS

MONEL® • "R"® MONEL • "K"® MONEL
"KR"® MONEL • "S"® MONEL

• • •

NICKEL • LOW CARBON NICKEL
DURANICKEL®

• • •

INCONEL® • INCONEL "X"® • INCOLOY®
NIMONICS

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

IMMEDIATE DELIVERY

From Stock

fully armored all-metal FLOWRATOR meters

Delivery right from Fischer & Porter stock in Chicago, Dallas, Los Angeles and Hatboro means much to you.

Now you can have the wide range, linear scale Fig. 52 all-metal meter quickly in 150 lb. and 300 lb. ratings in steel or 316 stainless. These meters are complete meters and not just metering elements, are low in price and may be equipped with Magnabond pneumatic transmitters (illustrated) or all-metal magnetic indicators which are regularly stocked. Six sizes in FLOWRATOR Meters will cover a capacity range from a *fraction* of a GPM (or SCFM) to 240 GPM (or 850 SCFM). Each meter, with Stablvis float, has a viscosity immunity well above that found in orifice practice.

Further, Fig. 52 meters can be changed for different applications—right in the field—by use of the information contained in the F & P Variable Area Handbook.

If you would like further information on Fischer & Porter Flowrator Meters—or a free copy of the Variable Area Handbook—check and return the handy coupon now!

5 DISTINCT FEATURES:

- One moving part, no stuffing box
- Wide rangeability
- Viscosity immunity
- Linear calibration
- Safe, all-metal construction

Fig. 52 Flowrator Meter equipped with Magnabond pneumatic transmitter.

FISCHER & PORTER COMPANY
2380 COUNTY LINE ROAD, HATBORO, PENNA.

☐ Please send me by return mail complete information on your Armored Flowrator Meters.
☐ Please send Variable Area Handbook.

NAME_____ POSITION_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____ ⊕1740

HOW TO FIGURE THE COST OF STEAM TRAPS

STEAM TRAPS are something like wives. First, there is the cost of securing one and installing it in its new home. Then, there is the cost of maintaining it. Now, everyone knows that some wives are frugal and help their husbands a great deal, while others are frivolous spendthrifts. It is the same way with steam traps. You have to figure the original installed cost, the maintenance cost and the effect on general operation.

Divide the total expenses by life of the trap and you get down to the real heart of the matter—the *cost per year.* This is where Armstrong steam traps really shine! Let's take a look at the details:

DIRECT TRAP COSTS

1. First Cost. The price of Armstrong traps is low in terms of capacity. An optimum relationship between leverage, bucket weight, bucket travel and orifice size gives big capacity in a small package. Armstrong steam trap capacity ratings are based on *actual* tests with condensate at steam temperature and with actual hookups. They tell you what the trap will deliver *on the job.* This is not generally the case with other trap ratings.

2. Installation Cost. In four of the most widely used sizes, Armstrong traps are available in either side inlet—side outlet or bottom inlet—top outlet body styles, making possible the simplest, lowest cost installation.

3. Maintenance Cost. 40% less maintenance with Armstrong traps is the average of all the maintenance reduction reports secured from users over a period of years. This is due to high quality of parts, generous safety factors and inverted bucket know-how.

4. Repair Parts Cost. Armstrong heat treated chrome steel valve parts, precision ground and lapped, last a long time. When they do require renewal, a complete new valve mechanism right off the factory production line transforms an old trap into a new one at low cost.

INDIRECT COSTS

1. Cost of Steam Waste. This cost occurs through leaky trap valves, through traps that stick open or lose prime, through extra hours of operating heat transfer equipment due to poor drainage. This is a cost you can eliminate with Armstrongs.

2. Cost of Efficiency Losses. Poor trapping cuts heat transfer efficiency. Figure how much 10% loss affects the return on a $5000 production unit, or a $1,000,000 plant. Armstrong traps discharge condensate and air as fast as it accumulates, keep steam equipment at peak productive efficiency.

3. Cost of Downtime. Armstrong traps stay on the job long and faithfully, eliminating the production losses caused by excessive downtime for maintenance.

A steam trap casts a mighty big shadow that is multiplied by the number of traps in a plant until it has a major effect on operating costs. When you figure the costs from all angles you will find it pays to specify "traps shall be Armstrong."

FREE: **STEAM TRAP BOOK**

—44 pages of prices, design, selection, installation and maintenance data on Armstrong steam traps. You are welcome to a copy. Call your local Armstrong Representative, or write.

ARMSTRONG MACHINE WORKS

852 Maple Street • Three Rivers, Michigan

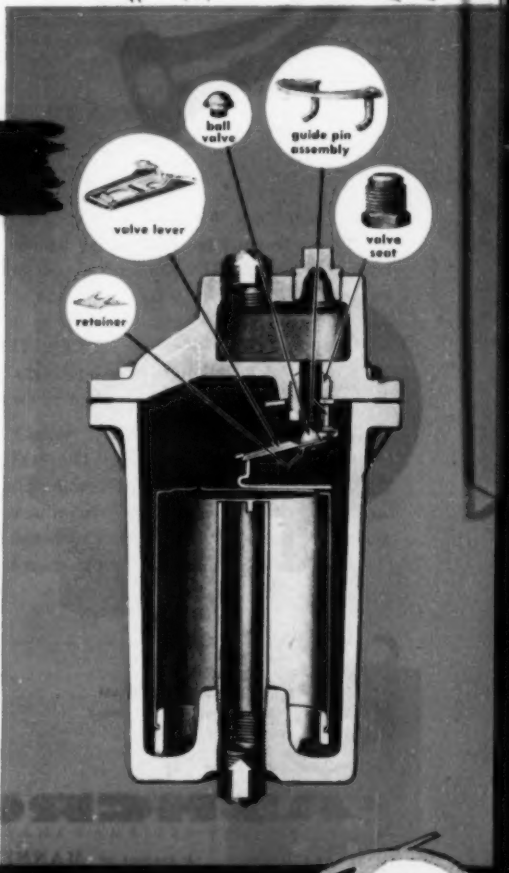
ARMSTRONG

YOU CANNOT BUY A BETTER TRAP THAN AN ARMSTRONG . . .

Here Are Some Questions for Cost Comparison

1. Will the valve stay steam-tight for 2 to 3, or even up to 10 years depending on the service?
2. Will the trap discharge condensate at steam temperature to keep equipment hot and minimize non-productive radiation losses?
3. Will the trap automatically discharge air in sufficient volume to keep equipment at peak temperature and to prevent corrosion?
4. Is there enough safety margin of power in the bucket and lever to open the trap when the orifice enlarges slightly due to wear?
5. Can the trap stick in open position?
6. Is the trap apt to lose prime?
7. Are the published trap capacity ratings accurate and reliable for trap selection purposes?
8. Will the trap cleanse itself of ordinary dirt and scale?
9. Is the trap easy to install, inspect and repair?
10. Is the trap unconditionally guaranteed to give complete satisfaction?

If the trap is an Armstrong, the answer to each of these questions is favorable!



STEAM TRAPS COST LESS!

8 BOURDON TUBE MATERIALS

MAKE IT EASY TO SELECT THE RIGHT ASHCROFT DURAGAUGE FOR YOUR PARTICULAR NEEDS

- **Phosphor Bronze**
- **S. A. E. 4130X Alloy Steel**
- **S. A. E. 4650 Alloy Steel**
- **"K" Monel**
- **Type 316 Stainless Steel**
- **Type 347 Stainless Steel**
- **Type 431 Stainless Steel**
- **Beryllium Copper**

Service conditions and requirements determine what Bourdon Tube material is best in the pressure gauges you buy. To insure sustained accuracy and maximum durability in specific installations, Ashcroft Duragauges are available with Bourdon Tubes *in any one of the 8 listed materials.*

All Bourdon Tubes used in Ashcroft Duragauges are extra-wide–have greater sensitivity to slight pressure change. Pulsating pressures 50% higher than the tube rating remove any possibility of tube "set", and all tube joints are stress relieved after assembly. You can select with complete confidence that your Duragauges will serve accurately under the working pressures and corrosive conditions common to your operations.

Ashcroft Duragauges have other features important to you. The Nylon Movement* outwears all others. Unusually long tip travel assures greater accuracy of indication. The micrometer adjustment pointer can be reset while on the shaft. Precise recalibration of gauges in the field is easy. Sturdy lifetime cases, in a choice of materials, are available for stem, wall or flush mounting.

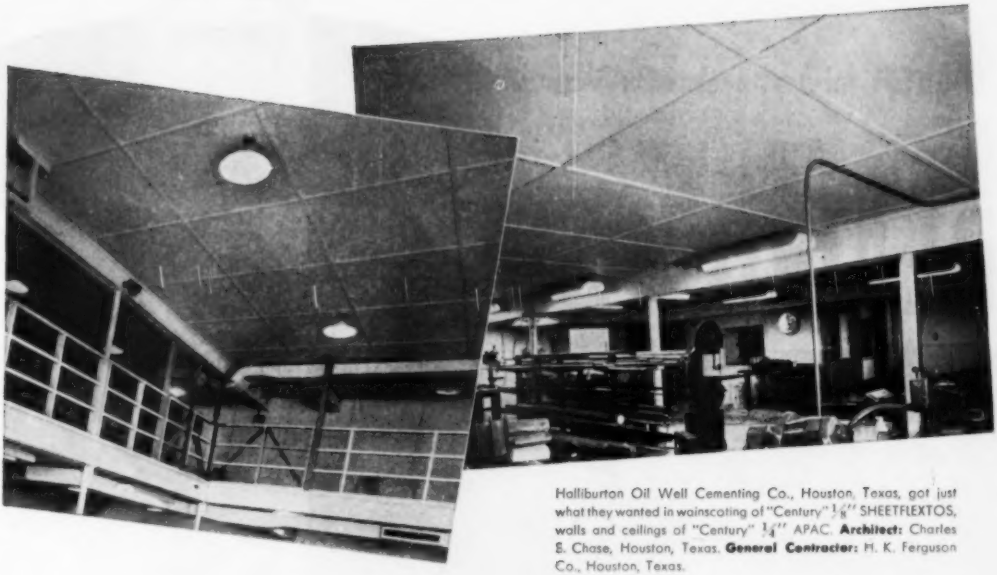
The nearby Ashcroft Distributor will gladly help you choose the right Duragauges for your particular service.

*Patented

ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'ASHCROFT' GAUGES, 'HANCOCK' VALVES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' INDUSTRIAL INSTRUMENTS, BUILDERS OF "SHAW-BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.



Halliburton Oil Well Cementing Co., Houston, Texas, got just what they wanted in wainscoting of "Century" $\frac{1}{8}$" SHEETFLEXTOS, walls and ceilings of "Century" $\frac{1}{4}$" APAC. **Architect:** Charles S. Chase, Houston, Texas. **General Contractor:** H. K. Ferguson Co., Houston, Texas.

Walls without worries

. . . ceiling without overhead

with **"CENTURY"**

ASBESTOS-CEMENT SHEETS

Halliburton Oil Well Cementing Co. wanted strong, good-looking walls and ceilings that would be *fire-resistant* and *easy to clean*. That's why they chose "Century" SHEETFLEXTOS for wainscoting applied over solid sheathing and "Century" APAC secured right to studs and joists for upper walls and ceilings.

Fire-resistance, of course, is an outstanding feature of these structural boards, combined as they are of virtually indestructible asbestos fiber and portland cement. Ease of cleaning, too, comes "naturally" to their hard, smoothly-textured surfaces that can't be hurt by water, dampness, or rot, and need no protective painting.

But look at the *extra* features that go with "Century" APAC and SHEETFLEXTOS. Both Sheets are also resistant to rodents, immune to termites. They go on fast, in big sheets (standard 4′ x 8′) that can be cut or drilled on the job, and fastened easily with screws or ring-fettered nails. They obviate the need for laths and plaster, and, while they require no painting at all, they take decorative colors well. SHEETFLEXTOS, as its name implies, has the added advantage of flexibility, to make curves and domes where indicated.

Both "Century" APAC and "Century" SHEETFLEXTOS make good surroundings for successful work and enjoyable living. Figure on one or both for your attractive, fire-resistant interiors. Write us for further details about these economical products . . . and name of your nearest distributor.

Nature made Asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

K&M — Last in asbestos

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

BEAIRD

CAST STEEL FITTINGS

Flanged fittings

Screwed fittings

Return bend fittings

Soundly Engineered and Accurately Machined for True Fit and Long Service

Beaird fittings have been developed over the past two decades to give you a product of exceptionally high quality. Whether you are planning new plant construction or require fittings for replacement, you will find that Beaird cast steel fittings are outstanding for accurate fit and long service. Five points of superiority, incorporated in their design, have made Beaird fittings the preference of petroleum and chemical companies around the world.

Why Beaird fittings are superior:

- **Heavier walls**
- **Completely backfaced flanges**
- **Concentric bores**
- **Uniform gasket surfaces**
- **True flange circumference**

Ask your supply house for Beaird cast steel fittings — or write to us direct for a quotation on your requirements.

SINCE 910

BEAIRD

SHREVEPORT

Fittings That Fit

THE J. B. BEAIRD COMPANY, INC. **SHREVEPORT, LOUISIANA**

PACKAGED COMPRESSOR PLANTS

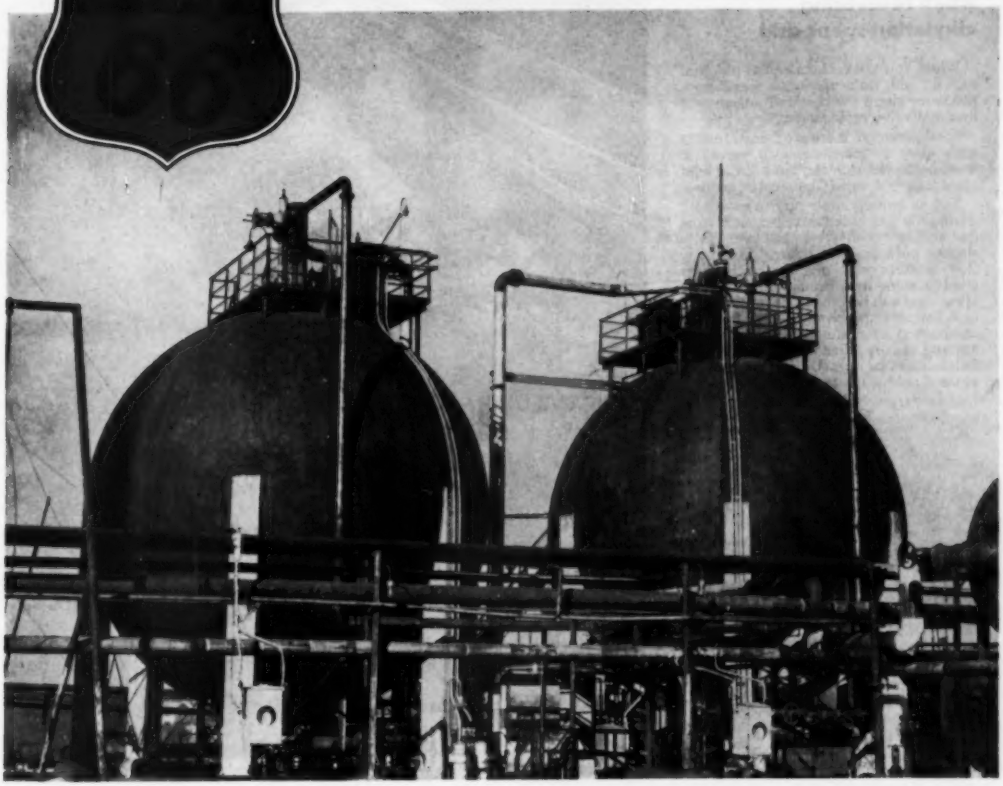
L.P. GAS SYSTEMS

ANHYDROUS AMMONIA EQUIPMENT

PRESSURE BULK STORAGE

MACHINING
FABRICATING
STEEL WAREHOUSE

another leading refiner who desalts with PETRECO



Phillips Petroleum Company has earned a place of leadership in the oil industry by manufacturing and marketing products of the highest quality. To consistently produce excellent products, a refining organization must possess and utilize a high degree of technological know-how.

One phase of Phillips know-how is their insistence on the absolute minimum of residual salt in the crude charge. Like other leading refiners, Phillips knows that salt in the crude charge, even in nominal tolerances, is a certain trouble-maker. The fact that Phillips utilizes Petreco Electrospheres at Phillips, Texas, to hold the salt content of the crude charge to this refinery to their required low minimum is of considerable significance.

Like other leading refiners everywhere, Phillips not only produces the best products possible–they help to assure this excellence of product by utilizing Petreco Desalting, the desalting process with an established reputation and known standards of performance and service.

Complete information on Petreco Electric Desalting and other refinery processes is yours for the asking.

PETROLITE CORPORATION
PETRECO DIVISION

3202 S. WAYSIDE DRIVE, HOUSTON 3, TEXAS
1390 E. BURNETT ST., LONG BEACH 6, CALIF.

PETRECO

ELECTRIC PROCESSES FOR THE PURIFICATION OF PETROLEUM

CRUDE OIL: **REMOVAL OF SALTS, SOLIDS AND OTHER IMPURITIES; DEHYDRATING**
DISTILLATES: **ACID, CAUSTIC AND DOCTOR TREATING**
FUEL STOCKS: **DESAPONIFICATION**

PR 52-4

It takes a corrosion-resistant valve to stay on the job when recovering alkylation spent acid

When you are reclaiming 98 per cent sulfuric acid from alkylation spent acid, you can't afford the cost and nuisance of frequent valve replacement.

For that reason, there are many ALOYCO high alloy corrosion-resistant valves at work in the Houston contact sulfuric acid plant of Consolidated Chemical Industries.

This is one of three such plants built during the war to convert spent acid from the sulfuric acid alkylation process to strong, pure acid. It differs principally from sulfuric acid plants operating on sulphur alone by a furnace in which the spent acid can be broken down to SO_2 at high temperature, brought about by using combustion air preheated in a recuperator, and usually auxiliary fuel gas as well. Sulphur can be burned simultaneously or alone if acid is not being recovered.

ALOYCO valves give long-lasting, corrosion-free service at the alkylation spent acid recovery plant of Consolidated Chemical Industries Inc., Houston, Texas.

ALOYCO valves have been giving corrosion-free service for many years in the strong acid circuit, the sludge acid area, and in the gas purification section.

If your plant deals with such severe corrosives as sulfuric acid, let the *Aloyco Corrosion Clinic* recommend the right high alloy valve to eliminate corrosion.

Corrosion-resistant high alloys are under constant study at ALOYCO's metallurgical laboratory. It is ready at all times to help you guard against corrosion.

ALLOY STEEL PRODUCTS CO., INC.
1303 West Elizabeth Avenue, Linden, N. J.

Longer Lasting
ALOYCO VALVES
1st in Corrosive Service

Lasts longer in corrosive service

ALOYCO sampling valves are functionally designed for convenience and dependability.

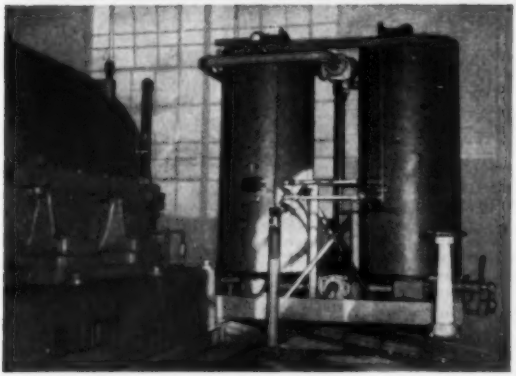
Like all ALOYCO valves, these specialized valves are the result of extensive metallurgical research and engineering and the production of high alloy valves exclusively.

ALOYCO No. 733 Sampling Valve has an ingenious expansion chamber which enables samples to be taken without splattering.

DRYing with Lectrodryers

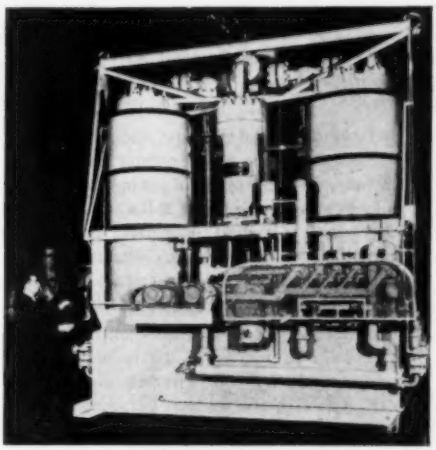
Instrument air controlling a city gas plant

Compressed air in this system controls and records the flow of butane to preheaters, where it vaporizes. The Lectrodryer* keeps that air DRY; no freeze-ups of lines or clogging of delicate instrument ports.



Butane standby for a metropolitan gas system

Manufactured gas used for forcing butane out of the barge tanks in which it arrives at the plant, and again for forcing it into the vaporizing equipment, is dried by this Lectrodryer. Thus, there's no chance of moisture getting into the tanks.



Gases at 5,000 psi. in research work

A package unit, ready to run, but so big it had to be shipped on a depressed-bottom car. Yet this Lectrodryer only needed to be connected to feed lines and it was ready for action. Fully automatic, it reverses the DRYing-regenerating cycle at predetermined intervals.

Whatever your DRYing need—atmospheric or high pressure, small or large volume, manual or automatic control—Lectrodryer can handle the job. For DRYing help, write Pittsburgh Lectrodryer Corporation, 307 32nd Street, Pittsburgh 30, Pa.

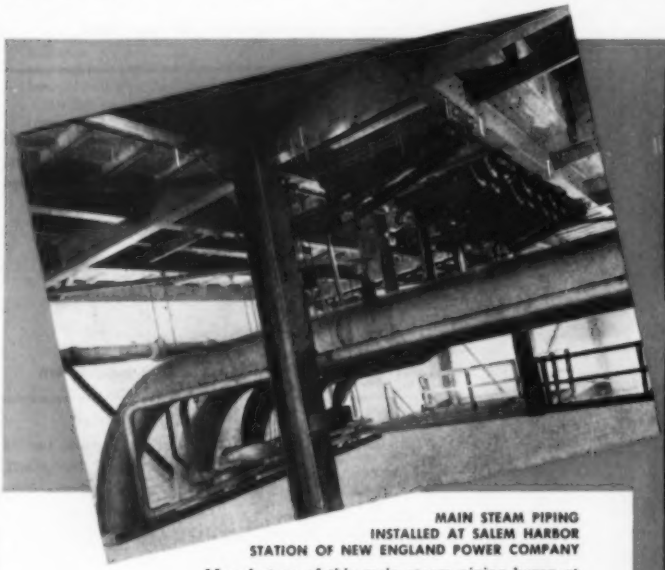
In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In Australia: Birlec, Limited, 51 Parramatta Road, Glebe, Sydney.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

*REGISTERED TRADEMARK U.S. PAT. OFF.

What it takes to make steam behave *at 1450 psi and 1000° F!*

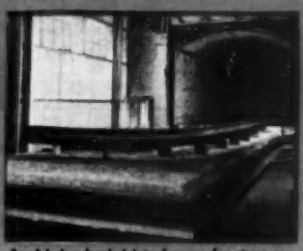


MAIN STEAM PIPING INSTALLED AT SALEM HARBOR STATION OF NEW ENGLAND POWER COMPANY

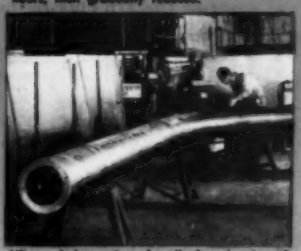
Manufacture of this main steam piping began at Pennsylvania Forge Corporation as 20-ton alloy-steel ingots (2¼% chrome, 1% moly steel). Four days' forging changed the ingots into solid bars 30 ft. long, with outside diameter of 15½ in. Boring, turning, sizing and finishing followed.

Bending furnace raises pipe temperature to 2000°F in 3 hours, 40 minutes. Thermocouples and pyrometer measure pipe temperature.

Skilled team completes bend in six minutes. Inside surface temperature dropped about 100°F.



Bend being loaded into furnace for stress relieving. Heat maintained at 1425°F for 4½ hours, then gradually reduced.



Ultrasonic inspection of wall after cleaning of pipe shows maximum thinning in bend of 1/16 inch.

FABRICATION of the main steam line for the Salem Harbor Station of the New England Power Company, vital link in more than 52 miles of piping fabricated by Grinnell, is an example of the *many* skills required of Grinnell piping specialists. Grinnell chemists, metallurgists, physicists, radiologists and supersonic electronic scientists . . . *all* played a part in the bending, welding and testing operations.

The integration of complex, highly technical skills like these into a *single* organization of trained specialists explains Grinnell's leadership in the field of prefabrication. It explains, too, why your interests are best served when you call upon Grinnell's expert personnel and specialized facilities in the solution of your piping problems.

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industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

Our Readers' Comments

Good Idea!

Dear Sir:

The department of the PETROLEUM REFINER devoted to "Science and Technology" abstracts could be improved by furnishing the authors' addresses for the abstracted articles. Most authors are prepared to forward reprints of their papers upon request.

If you furnish the addresses of the authors, there would be no need to refer to another publication in order to request copies.

FRANK L. RUBIN,
Catalytic Construction Company,
1528 Walnut Street,
Philadelphia 2, Penna.

Ed. Note: Sounds like a very good idea to us. Starting with this issue Drs. Leslie and Coates have the addresses listed with the abstracts.

"Security"

Dear Sir:

"The Look Box" in your July issue raises the question, "What do they mean by security?" I believe that most engineers who are asking questions in regard to security do not want to accept employment from a company which:

1. Discharges men during a temporarily slack business period despite the fact that the over-all picture for the industry indicates continued growth during the ensuing years.
2. Discharges men in one department for lack of work and simultaneously hires other men for similar jobs in other departments.
3. Discharges men for lack of work and simultaneously offers them "other" jobs for lower rates of pay.
4. Discharges *entire* staffs of men during administrative shake-ups.
5. Keeps men in specific departments and prevents the growth and broadening of their professional status by limiting their job experience.
6. Presents a pension system designed to ensnare a man. Such a system does not recognize the fact that the vast majority of engineers work for four or more employers during their careers. These systems do not offer any real benefits (except for return of the employes' money) to those who find it necessary to change employers.

By the way, despite the purported shortage of engineering graduates, I happen to know that a B.Ch.E., class of 1952, has not been able to obtain employment. His salary demands and location requirements are reasonable; he has two years of on-the-job experience and received *an award* for the highest grades in his graduating class from an AIChE accredited school.

Name Withheld by Request.

Ed. Note: I know one too. He is a member of Tau Beta Pi and has 2 years of experience.

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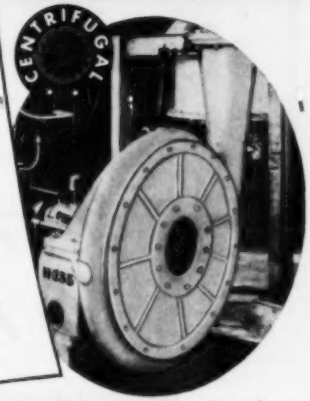
- ☐ Customer satisfaction



Type OIB Centrifugal Blower in use by southern petroleum company. Capacity 2,000 cfm. Motor driven through gear.

If you are considering new equipment for handling gas or air, we suggest you examine the essential values listed above, before you make your final selection. These factors will help you determine the unit that will best match your specific application, and that will give you the most satisfactory, economical performance.

You'll find that R-C equipment rates high in every one of these essential factors. With capacities ranging from 10 cfm to 100,000 cfm or higher, at moderate pressures, and with the exclusive *dual-ability* line of Centrifugal or Rotary Positive types, you have a wide choice to meet the most exacting needs.

If you'd like to tell us about your specific problem, we'll gladly send detailed information for comparison, or supply engineering help from our 98 years of blower building experience.

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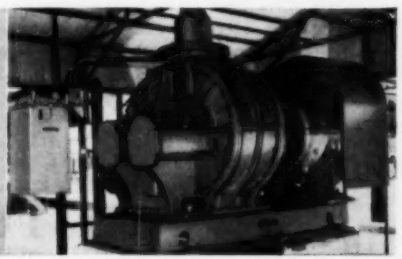
ROTARY

Type RCD Rotary Positive Blower for producing low-pressure air for asphalt oxidation still. Driven by squirrel-cage motor. Capacity 2,850 cfm.



Reg. U. S. Pat. Off.

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In Motor Gasolines

Du Pont Antioxidant No. 22 is one of the few inhibitors approved for military aviation gasoline.

In motor gasolines, too, it has proven to be one of the most effective gum inhibitors, especially where caustic or water extraction is a factor.

It is not subject to extraction to the same degree as some other types of antioxidants because it is almost completely *insoluble* in water and caustic. Even where gasoline is subjected to agitation in the presence of water, Antioxidant No. 22 generally gives excellent results.

This insolubility is especially useful when the antioxidant is added to hydrogen sulfide-free stock prior to doctor sweetening or caustic washing. Here it takes advantage of the superior response of fresh gasoline to antioxidant addition and prevents deterioration in cases where the gasoline must be stored prior to finishing.

Du Pont Antioxidant No. 22 contains no solvents or diluents. It is commercially pure N:N'-di-secondary butyl-para-phenylenediamine.

To determine the effectiveness of Du Pont Antioxidant No. 22 accurately in your own gasoline stocks, storage tests—rather than accelerated tests—are recommended. If you have any antioxidant treating problems, the nearest Du Pont district laboratory will be glad to help you determine the most effective and economical means of using additives. This help is also extended to refiners who have recently changed stocks or have changed their stability requirements.

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PETROLEUM REFINER

The LOOK BOX

OIL PROGRESS WEEK EXHIBIT—Advances made in the manufacture of better gasolines during the past quarter century are dramatized by means of a striking exhibit, pictured above, prepared by the Oil Industry Information Committee for display by local oil men during and after Oil Progress Week.

The exhibit features the "2 = 3" theme developed as the result of road tests recently conducted on the New Jersey Turnpike and used by the committee in newspaper advertising, on the radio and TV and in a new motion picture by that name, as well as Oil Progress Week billboards and posters. It also depicts typical activities in the four major branches of the petroleum industry—production, refining, transportation and marketing—and illustrates a number of oil uses in the average American home.

Oil Progress Week will be held from October 12 through 18 this year. Oil men and oil companies by the thousands in all parts of the United States will invite public attention, during that seven-day period, to the petroleum industry.

Watch For The Process Issue

THE 1952 Process Issue of PETROLEUM REFINER promises to be another banner edition in this annual compilation of refining, natural gasoline, and petrochemical processes. Our last complete coverage of refining processes was in the 1949 September issue. In the intervening years our attention has been concentrated on the newest developments in processing. However, the time has come when we shall again cover the entire field. This year's September issue will be complete with approximately 100 of the most important processes and will serve for years to come as the process handbook for our readers.

In addition we are planning a monograph on the catalytic cracking technique. If you have felt the developments in this segment of the industry have been just too rapid to keep up with, here is your opportunity to bring yourself up to date.

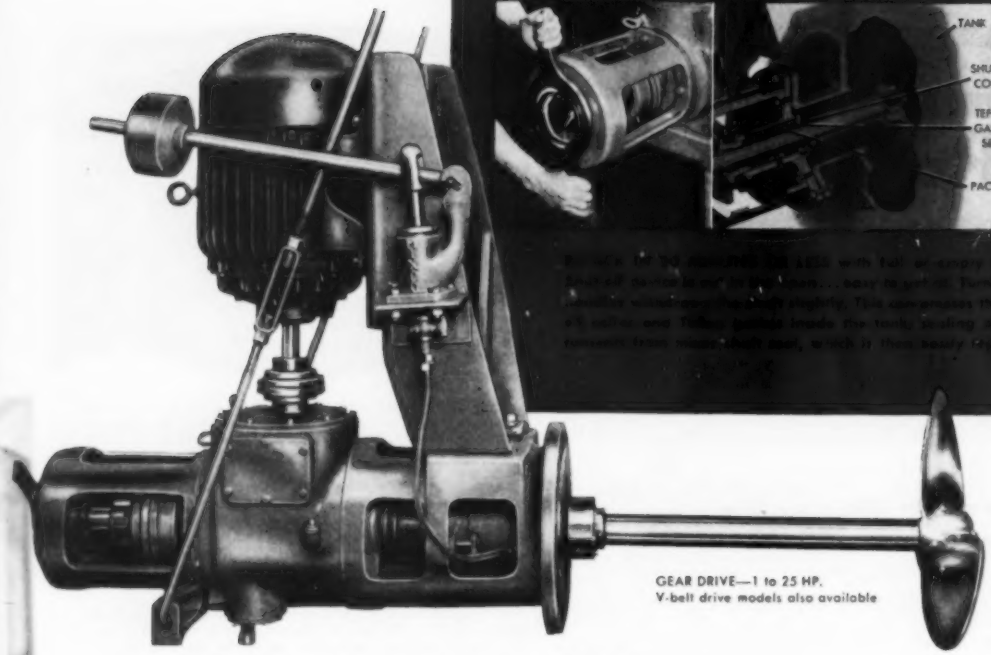
Washington's Cartel Schmartel

FOR MANY YEARS we have been proud of the progress made by our oil companies in producing and refining crudes on foreign soil. We know of the intense competition among these oil companies to extend their areas of production and to improve their market positions all over the free world. And still . . . Attorney General McGranery says there might be a cartel and that he will shortly institute a grand jury investigation. McGranery elected to announce his contemplated action against seven of the major oil companies in advance of the investigation.

In answer to our letter to him, S. A. Swensrud, president of Gulf Oil Coporation, said "Presumably the investigation will be conducted fairly. If it is, I am confident no charge against Gulf Oil Corporation will result from the investigation since Gulf is not a party to any cartel anywhere. Gulf is not disposed to waste its energies in protesting against such an investigation. If the Attorney General thinks, as he evidently does, that there is sufficient reason for such an investigation, it is his duty, as I understand it, to order the investigation to be made. I regret the time that Gulf will have to devote to the investigation and the expenses involved, but these cartel rumors involving Gulf should be stopped and, perhaps, for that reason the investigation will turn out to have been worthwhile, if it is fairly conducted."

Eugene Holman, president of Standard Oil Company (New Jersey), replied with similar remarks. He also stated "We can only assume that the Federal Trade Commission report contains charges that, if published would embarrass the government of this country in its foreign affairs. A Department of Justice investigation, therefore, would provide a chance to separate fact from fiction. If the investigation should present a forthright picture of the business practices of the companies involved, and discredit irresponsible inferences drawn from such a report, it would be a good thing. This is what we hope for."

J. S. Leach, president of The Texas Company, said "The contracts covering the Arabian concession, which is our principal jointly controlled foreign operation, were twice discussed with the then U. S. Attorney General in Washington in draft form before they were finalized and copies of the executed agreements were filed with the Department of Justice immediately after their execution. No objection of any kind was ever made to these agreements, and, in our opinion, the joint operations which The Texas Company



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V-belt drive models also available

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2. **SMOOTHEST OPERATION**—New compact design puts weight close to tank, cuts vibration to a minimum.
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4. **CHOICE OF SHAFT SEALS**—To suit your operating conditions exactly!
5. **EXTRA YEARS OF SERVICE**—High precision, specially matched quiet-running gears; exclusive hollow-quill construction to protect gearing; flexible couplings at *two points* for added safety. Many LIGHTNIN Mixers have been in service 20 years or more!
6. **NEW LOW PRICE**—Not the "cheapest" you can buy . . . but LIGHTNIN advantages make it the best buy for the money! May we prove this to you?

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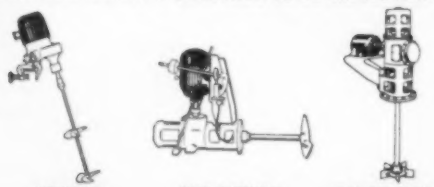

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- ☐ DH-50 Laboratory Mixers

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has entered into abroad are in the best interests of the United States as well as the foreign countries involved.

B. Brewster Jennings, president of Socony-Vacuum Oil Company, Inc., replied thus:

"To the best of our knowledge we conduct our foreign business in conformity with the applicable laws of the United States as well as complying with the laws of the various countries in which we operate.

"There has never been any secrecy about our foreign operations. The facts and agreements regarding them have been disclosed in reports to various government agencies and in investigations by Congressional committees.

"We have certain joint interests with a number of other oil companies in foreign operations, prominent among them being Iraq Petroleum Company and Arabian-American Oil Company. Our entry into Iraq Petroleum Company came directly at the instigation of the United States government. The interested departments at Washington were fully advised when we acquired the interest which we hold in Arabian-American Oil Company. These joint interests are not illegal combinations or cartels.

"We believe the foreign operations of Socony-Vacuum Oil Company, Inc., and other companies have been of great benefit to our country and that it would be tragic if the conduct of this investigation were such as to make further business activities outside the United States by American companies impossible. This would be a blow to the great effort to develop the economic strength of friendly nations, on which our country has staked so much. Ultimately, it also would depress our own living standards."

You forgot only one thing Mr. Jennings: This is one way to make Joe Stalin happy.

Fairly Sound Position Seen

BY THE END of August much of the ground lost during the recent refinery strike probably will be regained and the industry should be in fairly sound economic position. Prospects are good for refined product stocks again to approximate year-ago levels and perhaps be in better position than they had been before the shutdown. The improvements would be found in the Mid-Continent states where excessive inventories were siphoned off by the labor lay-off.

Since the strike's end considerable improvement has taken place in distillate fuel oil stocks, and that has been done by record refinery operations. As distillate fuel supplies have been one of the industry's chief concern, this situation is very encouraging, and the outlook for sufficient wintertime quantities now becomes brighter.

Distillate inventories were 8 million barrels behind 1951 volumes at the end of May, when the refineries went back on stream, and were 6½ million barrels under year-before volumes by end of June. Currently, these stocks are only slightly more than 4 million barrels behind and growing rapidly. Recently these stocks were increasing at the rate of 520,000 barrels daily in contrast with daily gain of 445,000 barrels last year.

Prospects that refinery operations will be at peak levels during August indicate that further reductions of the two years' margin of difference will be made. Chances are very good that distillate fuel stocks will reach last year's levels by the close of the month. Then continued high refinery runs during September and October could boost these inventories enough higher than last year's to amply meet winter's anticipated requirements.

Improvement also is being shown in gasoline stocks. High output rates are allowing them to decline at a slightly lower seasonal rate than last year's. With the high refining rates that are in store for the coming months, there appears little need for concern over adequate supplies for the summer's heavy requirements.

Technical Unions—Yes or No?

IN THIS ISSUE WE are trying something new and different in offering our readers informed opinions of both sides of a controversial issue. The question of the desirability of unions for technical professionals has gained nation-wide attention as a result of recent organizing efforts. Virtually all technical magazines have commented editorially on the subject. Almost entirely, editorial sentiment has been against such organizations.

The PETROLEUM REFINER editorial staff, composed entirely of technical men, most certainly has an opinion. We feel, however, that our opinions have considerably less value than those of the experts. For this reason, we have gone to the men who should really know the answer to the question "Are Technical Unions Beneficial to Members?" and offered them our pages to give their replies. Turn to the next pages.

We asked a technical union, that is in business, to give the affirmative views. The Association of Industrial Scientists, representing the technical men at Shell Development Company, present clearly and unequivocally the "yes" answer. We knew of no one man to turn to that could present a composite of the opposing view. To solve this, we sent one of our writers to interview executives in a wide cross-section of the petroleum and petrochemical industries. Their side of the question is reported on the page opposite the Union side.

It would be very amazing indeed if all of the important facts of the controversy have been covered by the two parties. Do you have something to add? If so, send in your comments and we will print them in the "Our Readers' Comments" section insofar as space permits. What do you think of this idea of bringing important issues out in the open where both the pros and cons can be fairly debated? We would like to know your reaction.

Are Technical Unions

YES! Say Unions

Association of Industrial Scientists,
P. O. Box #3, Emeryville, Calif.

BECAUSE of the demonstrated inadequacy of their individual efforts, professional employes are turning to group efforts to attain those economic and professional levels which not only are commensurate with their contributions to society, but which also are prerequisite to their maximum productivity and efficiency. The group efforts have taken the form of independent bargaining unions, the policies of which are controlled by the professionals themselves.

Throughout recent years, the need of professional scientists and engineers for improved economic reward has been recognized by diverse interests. Representative of such views is the observation by *Fortune* magazine (October, 1948) that ". . . in a heavily monetary society like our own it will be disastrous not to recognize that scientists must be scaled into the economy at a level more commensurate with their attainments and importance to society."

Because of their unattractive economic position, competently trained scientists are in such short supply that Dr. Lee A. DuBridge, president of the California Institute of Technology, has termed the shortage "close to a national calamity." It should be of no surprise to businessmen that increased salaries for scientists and engineers were advocated by Dr. DuBridge the prime remedy for the situation.

It has not been generally realized that the value of the professional technologist to his employer also depends, and to an inordinately high degree, upon his own belief that he has attained the proper economic and professional levels. This dependence exists because of the varying nature of professional work which has no set standards of comparison. Compared with the production worker, the productivity of the professional technologist involuntarily is more dependent upon his morale which in turn is molded by his salary, working environment and sense of worthwhile contribution to society.

But let there be no misunderstanding that the aspirations of the professionals are incompatible with management's drive for maximum profits. Technologists realize that in the long term real wage increases can only come about through increased productivity, and unions of technologists have reflected this viewpoint. Feather-bedding and make-work policies of reactionary labor unions are completely foreign to the thinking of unions of professionals.

If further arguments be needed to emphasize the desirability of higher salary levels for technologists, let it be realized by business management that the level of executive salaries in the chemical and petroleum industries rests inexorably upon the level of professional technologists' salaries; and it is these executive salaries that have been found (*Business Week*, March 1, 1952, p. 102) as suffering relatively the greatest during the period from 1939 to 1950.

The professional union offers the most promising means for attaining the proper economic level. In addition the professional union strives to enhance the professional status and competence of technologists, and materially aids management in establishing a satisfying relationship with them. Some contend that management alone can handle these problems. Advocates of this contention, aside from ignoring the positive contribution of unions to the success of the business, overlook the fact that there are differences in basic attitudes between professional technologists and the rest of the business organization. In its treatment of the professional employe, the modern business organization acts, perhaps necessarily, in an impersonal and autocratic manner which at best may be characterized by benevolent paternalism. For better or worse, the pro-professional technologist wishes to participate in the formation of various personnel and fiscal policies which affect him. Peter F. Drucker, professor of management, New York University, has expressed (*Harvard Business Review*, May-June, 1952) the situation as follows: "But the fact still remains that the professional group demands self government in respect to personnel practices. That business today imposes personnel practices on him is perhaps his greatest grievance." It is in the solution of this apparent dilemma that the union of professionals may perform one of its paramount functions. Counter-balancing the regimentation inflicted by the large business organizations, the union provides a forum where issues may be debated freely without management domination or influence. It provides a direct route of communication, without dilution or distortion, for transmitting the crystallized opinions of the professionals to top management. On the other hand, advantage may also be taken by management of this means of communication to keep the employes informed on various matters.

The professional union serves to benefit industrial and scientific development by encouraging individual initiative. The record shows that these unions have vigorously championed the principle that general cost of living and productivity raises must be granted on a percentagewise basis to combat the levelling of salaries that has tended to diminish the rewards customarily given for creative and highly skilled endeavor as compared to routine production work. Furthermore, these organizations have advocated, and indeed have cherished the principle that a wide spread of salaries, based on merit as judged by the employer, is desirable in order to encourage individual initiative.

The union may serve as a bulwark for the protection of the individual against unfair and discriminatory actions by lower echelons of management who actually may be jeopardizing and thwarting enlightened personnel policies of the employer. By its buffer action, the union actually can aid the employer in providing a degree of stability of operation and employment which is vital for the successful fruition of creative endeavor. The union can ameliorate precipitous action which might prove disastrous to the future of the employer. The prime example of ill-conceived precipitous action which has occurred repeatedly in recent years is the sudden reduction in research and development staffs by some large corporations. Secure working conditions are absolutely essential to successful creative scientific work. Intelligent management will effect re-

• See "Yes," page 55.

Beneficial to Members?

NO! Says Management

as told to AL REESE
Petroleum Refiner Staff

THE technical man who enters a union may be abandoning the path to his life's ambition to chase the mirage of temporary financial gain.

This was the warning voiced by executives of both technical and nontechnical backgrounds in reply to PETROLEUM REFINER'S question: "Are technical unions beneficial to members?"

The majority felt that technical men who join a union are:

- Raising a barrier between themselves and the management whose jobs they should otherwise logically inherit.
- Promising to slow their footsteps to the snail's pace of the least capable person in their group.
- Risking a ceiling on their earning capacities.
- Taking on another boss—and one who may be more exacting than any company supervisor.
- Placing themselves in the position of being forced to imperil their own interests on behalf of other union groups whose work and ideals are utterly foreign.
- Running the risk of giving up the high dreams of fame as an engineer or chemist to accept a life within the ranks.

A summation of these opinions was the general puzzlement as to why a technical man should want to join a union. One executive pleaded for an answer to this:

"Why should a technical man deliberately antagonize management, vitiate his ambition, submerge his individuality, saddle himself with a union boss, and shackle himself with union rules—all for the promise of a few more dollars and a little more recognition now in lieu of many more dollars and boundless recognition later on?"

Another executive's puzzlement was expressed in these words: "A professional man . . . is essentially an individualist. He is a college man, highly trained, intelligent and capable of making his own decisions, rising, falling or standing still upon the basis of his individual ability, imagination, effort, initiative and accomplishment. . . . The professional character of these employes is recognized; they are dealt with on an individual basis; are compensated on the basis of merit ratings; promotions are made on the basis of individual ability; complaints are considered by supervisors within their own professional groups.

"The benefits of professional status would, in a large measure, be lost if the professional employes . . . elected to form a labor group which would deal and speak, as a group, for a number of individuals with differing abilities, energies, hopes and aspirations."

The anomaly of a union bridge between management and the technical men was stressed by another: "Since the technical employes are, in fact, an inclusive part of management, regardless of whether they be considered as a staff or engaged in supervisory work, they certainly require no association or agency to represent them with management. Each day they are submitting reports to the higher echelons of management and working closely with plant superintendents, managers and vice presidents in charge of manufacturing. They are in daily contact with all echelons of management and they make the decisions which are normally called 'management decisions.'

"The question then becomes one of whether union card holders or members of labor unions should serve in these capacities," he added. "Most companies feel that employes who are making the decisions with regard to the proper use of the tools, the money, and the human beings in any organization are management itself and certainly are not proper groups to become members of labor unions or associations.

Some executives foresaw for the societies an embarrassed awakening to their true status the day a trade union asks—or insists—that the technical group respect a picket line or join a strike. It was conceded that the society would scorn such an overt act against management—the first time. But there would be constant pressure from the big and militant craft unions and constant reminders that the day might come when the small technical group would need their support. Thus would the society be gradually alienated from management, its natural ally, and become a working union.

Patience Urged

The youngest executive among those interviewed looked back to his own recent experience with a soothing word for the new graduates who compare their pay with that of union craftsmen.

Unionism began with, and was tailored to, the needs of men who lived by manual skills. The silversmiths, and other crafts requiring dexterity, demanded long years of apprenticeship as the price of admission to their closely held ranks. In this way they maintained a maximum standard of living and workmanship.

Then came the Machine Age, and craftsmanship gradually narrowed itself into specialized segments. As the machines improved, the work became more repetitive, more easily learned, and the training period was shortened. It became possible for most craftsmen to reach their maximum earning capacity in a comparatively short time.

By contrast, a technical man uses somewhat more time in passing through college, where he assimilates the fundamentals of his profession; and since he is not paid while learning, this period can be one of hardship. He emerges into the workaday world in no mood to tolerate the fact that the craftsman who has served a shorter training period is making as much money, or more, than he.

But, argues the young executive, there is no injustice here because there can be no comparison. The craftsman has reached the zenith of his earning power—except through cost-of-living raises or general increases based on increased productivity of his entire group. The technical man is just entering the secondary phase of his training. He is being paid more for his potentialities than for his contributions to the company. He has had an academic training but no practical training. He must now learn to apply his education to the particular problems of his company. This will require a year or two. Then, if he is industrious, there is no insurmountable barrier to the far horizon.

Of the executives interviewed, a few were frankly belligerent toward tech-

• See "No." page 55.

Oil Nearly $40 Billion Industry

$3.6 Billion Additional to United States Facilities in 1952 Continues Vigorous Postwar Expansion

BY THE end of 1952, the petroleum industry will have in the U. S. a total gross investment of approximately $40 billion. This estimate gives consideration to the heavy capital expenditures scheduled for this year. The industry's gross assets in the U. S. at the end of 1951 totaled approximately $36 billion, and during this year the industry is being further expanded by more than 10 percent. This continues the constant postwar expansion which had built the industry's gross investment in the U. S. up to approximately $33 billion at the end of 1950.

Greater Investment

The petroleum industry has an investment in the U. S. greater than that of any other "industrial" group, although less than agriculture, the railroads, and the public utilities.

In its vigorous postwar expansion, the industry has almost doubled its investment. In the seven years, 1946-1952 inclusive, its capital expenditures for facilities in the U. S. will exceed $17 billion, according to the American Petroleum Institute, including $3,621,759,000 being spent in 1952. Whereas it will be at the end of 1952 a $40 billion industry, petroleum was at the close of World War II little more than a $20 billion enterprise. Fifteen years ago, in 1937, its gross investment was approximately $13,725,000,000 (A.P.I.'s *Petroleum Facts and Figures,* Seventh Edition, 1941, page 178). The current total is practically three times that gross investment of 1937.

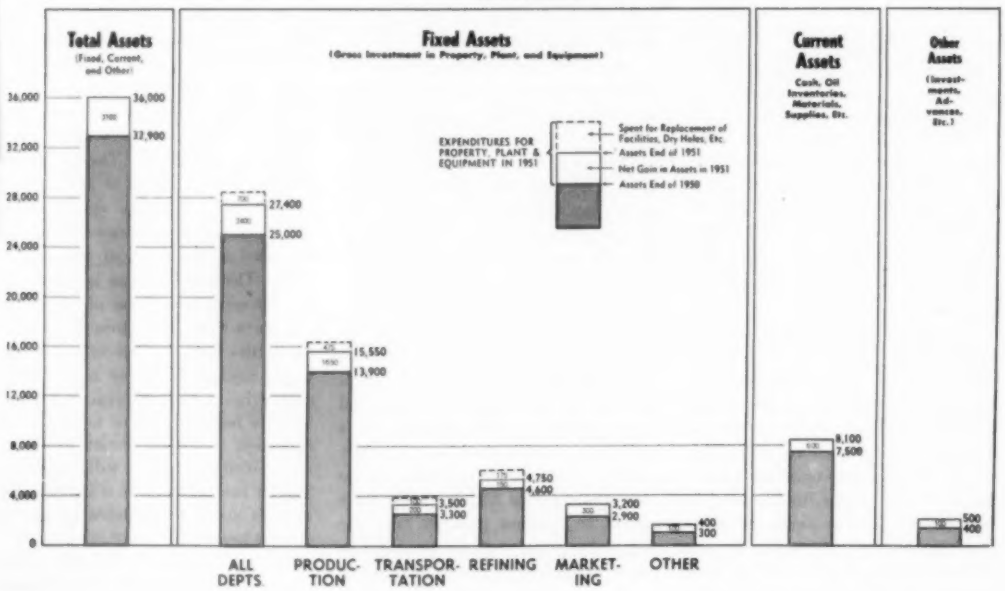
Inflated Costs

These large increases in the industry's capital investment reflect both a vast expansion of physical facilities and the inflated costs of all new facilities installed during and since World War II.

The capital expenditures made by the petroleum industry in the postwar period, including those scheduled for 1952, are shown in the tabulation of the American Petroleum Institute (Table 1). The table shows these ex-

Assets Employed (or Investment) in U. S. Petroleum Industry at End of 1950 and 1951 and Capital Expenditures Made in 1951

(MILLIONS OF DOLLARS)



Source: Chase National Bank Bulletin, "Financial Analysis of 30 Oil Companies for 1951."

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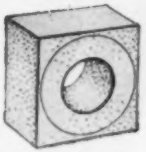
The Chief Engineer of a mid-western power plant finds B&W Kaocast so *versatile* that he always keeps a ton or more on hand for miscellaneous jobs. This is only one of hundreds of plants in a list of diversified industries which are discovering practical, time-and-money-saving uses for this unique 3000 degree refractory castable. The panel at right gives a few examples.

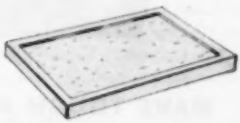
There are good reasons for these Kaocast "success stories". This jack-of-all-refractories can be molded in a hurry *by you, when you need it.* It can be cast directly in place or applied by cement gun. Kaocast not only makes possible faster repairs and eliminates the need for a large inventory of special shapes, but it also stays on the job. That's because Kaocast has high resistance to spalling and slag attack, low volume change and negligible re-heat shrinkage.

Get all the data on easy-to-use, versatile Kaocast from your B&W Field Engineer. His specialized experience is an important B&W "extra".

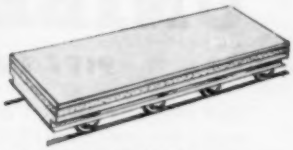
KAOCAST is another important refractories development by B&W engineers who have continuously established new standards in industrial furnace refractories for the past 30 years.



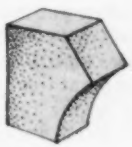
BURNER BLOCKS
Kaocast lasted 3 to 6 times as long as previous refractory. Still going strong.



DOOR LININGS
Kaocast lasted 3 to 6 times as long as previous refractory — cut installation cost in half.



TUNNEL KILN CAR TOPS
Ordinary fireclay crumbled after few trips. Kaocast lasted 30 trips without deterioration.



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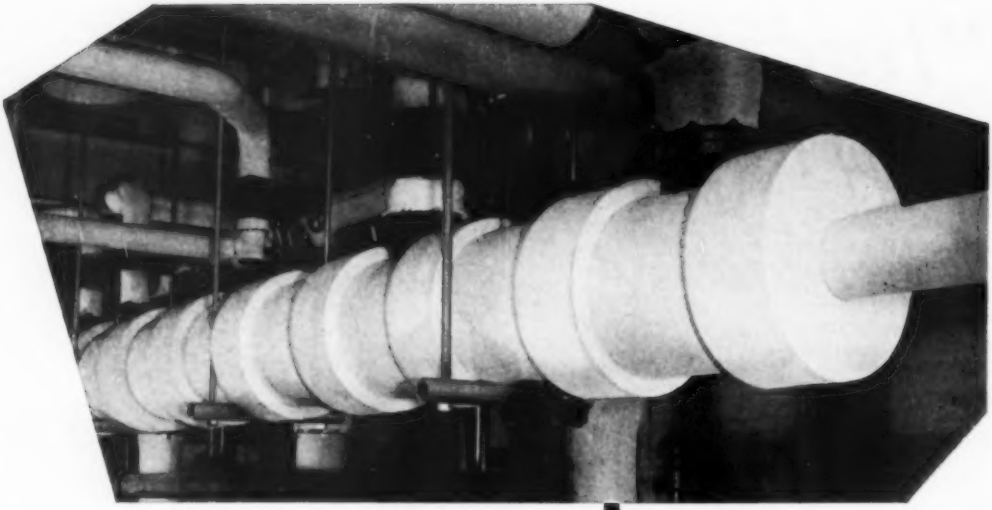

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For details on these insulations, ask for Bulletin No. 76-109.

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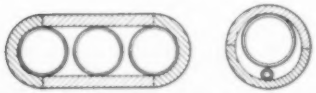
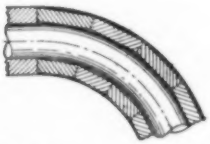
Unibestos pipe insulation is particularly adaptable for insulating irregular surfaces such as flanges, valves, and fittings. Its firmness and easy-to-fit characteristics make such jobs easy; save time.



Unibestos pipe insulation and block can be used separately or in combination for insulating nested and traced lines quickly and economically.



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penditures by all of the major divisions of the industry.

Including outlays for facilities in foreign countries, the American oil industry in 1952 will make capital expenditures exceeding $4 billion, and this amount will boost the industry's total (domestic and foreign) for the seven postwar years to more than $19 billion, according to the American Petroleum Institute's recent survey on this subject. This is described as probably the greatest expenditure of all time by any single industry for expansion and development over so short a period.

25 Percent Increase

The 1952 total of $4,085,762,000 represents an increase of 25 percent over last year's peak of $3,270,959,000. The total is believed to be on the low side, for while estimates are close for larger companies, the survey includes only a conservative estimate for the thousands of independent operators on whom no actual information was available.

These billions of dollars are being put into new oil wells, refineries, pipe lines, tankers and other transportation facilities, fertilizer and chemical plants, distribution outlets, and many other new, modernized, or expanded operations. This will require a continuing flow of vast supplies of steel and other materials.

The expansion is necessary to meet constantly increasing demand for petroleum products, which is now 43 percent higher than in 1946 and 73 percent higher than in 1941. Most of the money for the expansion must come from the earnings of the thousands of oil companies that make up the industry. The expansion program is described by the API as epitomizing the American way of life and the American way of doing things.

Expenditures Increase

Scheduled capital expenditures in 1952 are greater than in 1951 for virtually all divisions of the industry. Investment in 1952 for facilities in the U. S. will total $3,621,759,000. This amount will include $2,111,720,000 spent for production department facilities, including mainly wells and equipment and leases and also natural gasoline and cycling plants. Capital expenditures in the U. S. for transportation facilities in 1952 will total $547,502,000, including $400,402,000 for pipe lines and $119,890,000 for marine equipment, especially tankers and barges. Amounts being spent for pipe lines and tankers are substantially higher than in 1951. For refining facilities in the U. S., costs in 1952 will be about $565,740,000, or close to double the $302,950,000 spent in 1951. For marketing purposes, $288,950,000 will be spent in 1952, an increase of eight percent over 1951.

The natural gas branch of the nation's gas distribution and pipe line industry expects to spend $5,099,000,000 in its expansion program for the five years 1952-1956, compared with $4,560,000,000 spent in the preceding five years, 1947-1951, according to the recent AGA survey. Expanded transmission facilities will cost an estimated $3,075,000,000 in the next five years, with $415 million allocated to production facilities and an additional $82 million estimated for underground storage expansion. Other storage facilities will cost $38 million. For distribution facilities, $1,337,000,000 will be spent over the five years, and $152 million will go for general purposes.

Chase National Report

At the end of 1951 the petroleum industry in the U. S. utilized about $36 billion of gross assets, according to the Chase National Bank's recently issued pamphlet, "Financial Analysis of 30 Oil Companies for 1951" by Frederick G. Coqueron, petroleum department. The industry was described as one of the largest and most important parts of the country's economy. It gives direct employment to nearly 2 million workers; purchases vast quantities of steel, chemicals and other products, and in 1951 had gross operating income of $16.7 billion from sales of petroleum products and chemical and other products.

Are Technical Unions Beneficial to Members?

• CONTINUED FROM PAGES 50 AND 51

YES!

quired staff reductions by a process of attrition, i.e., by a policy of transferring personnel and ceasing to replace personnel who leave for natural reasons.

Those who oppose collective bargaining for professionals apparently assume that the worst features of conventional unionism must be intrinsic in organizations of professionals. This intolerant attitude is refuted by the existence and successful operation of several organizations of this type. These groups are independent unions, exclusively composed of and controlled by the professionals themselves. In the oil industry, two such organizations, certified by the National Labor Relations Board, are the Research and Engineering Professional Employes Association at Standard Oil Company (Indiana), Whiting, Ind., and the Association of Industrial Scientists at Shell Development Company, Emeryville, Calif. Outside the oil industry there exist more than 30 independent organizations representing more than 30,000 technologists in collective bargaining.

In conclusion, it is emphasized that the professional unions aim to advance the technical competence and economic and professional status of the technologist by collective action, while retaining for the individual the freedom necessary for the success of scientific and engineering endeavor.

NO!

nical societies, some were mildly antagonistic, more were frankly puzzled that "thinking men could be so mislead," and only one displayed tolerance.

No executive could deny that an employe has a real and vital interest in his financial well-being; further, each employe has a right to expect to be heard in this regard. All felt, however, that their companies provided sufficient and adequate salary review systems that eliminated the need for group action. The oil industry is one whose stalwart traditions were conceived and borne upward by strong daring men. The spirit of these men, performing as rugged individualists, is part and parcel of the industry.

Almost all of those contacted hammered home the point that technical men are the future executives—the "management." They vigorously deplored the establishment of any barrier to the technologist's conception of his real role with his company. They reasoned that if a technical employe honestly desires to become a part of management, how can he hope to do so by group action directed at thwarting the policies of his future colleagues?

Even if management in general could bring itself to accept with grace the technical unions, many will hold this uneasy thought in making promotions: He is more sheep than shepherd who must advance with the flock.

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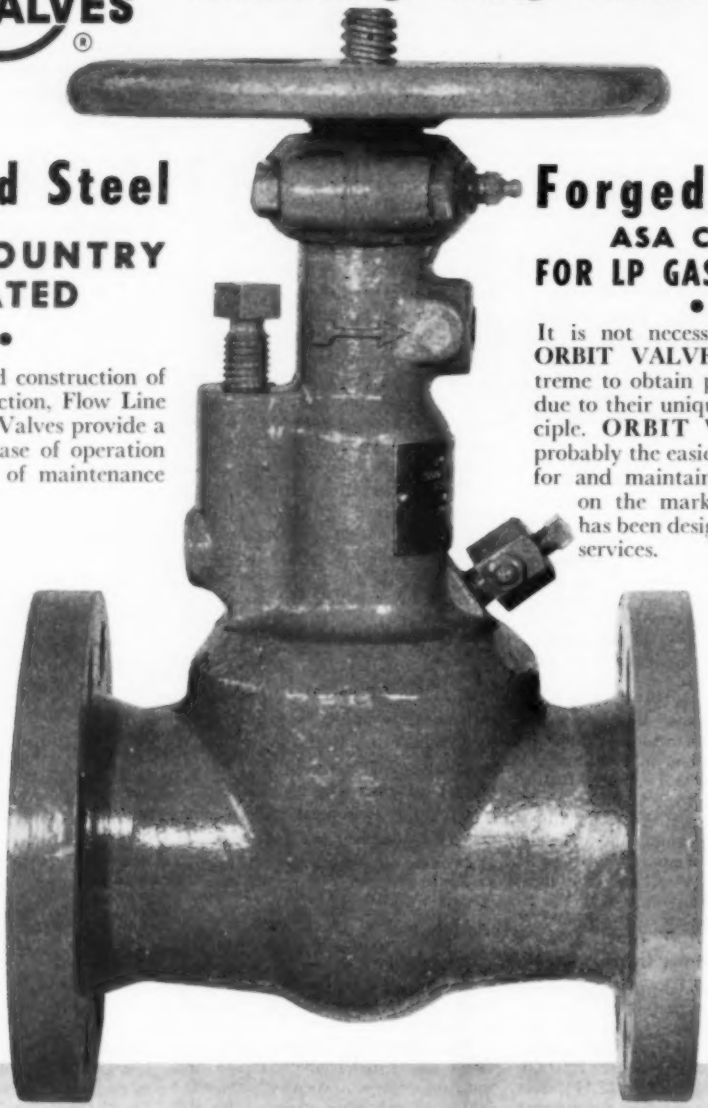

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TABLE 1

Oil Industry Capital Expenditures in 1952, 1951 and 1946-50

Source: American Petroleum Institute

(In Thousands of Dollars—000 Omitted)

	ESTIMATED 1952		ACTUAL 1951		ACTUAL 1946-1950	
	U.S.	*Foreign	U.S.	*Foreign	U.S.	*Foreign
Production: Total	**2,111,720**	**322,940**	**1,913,320**	**228,780**	**6,102,950**	**1,093,130**
Crude Oil, Total	1,925,450	312,670	1,758,020	215,600	5,467,790	1,022,370
Leases	250,180	23,140	288,850	12,200	1,110,170	84,630
†Wells and Equipment	1,675,270	289,530	1,469,170	203,400	4,357,620	937,740
Natural Gas, Total	65,290	1,080	65,450	2,700	196,570	4,510
Leases	11,340	.....	15,790	80	36,600	150
†Wells and Equipment	53,950	1,080	49,660	2,620	159,970	4,360
Natural Gasoline and Cycling Plants	82,170	4,900	52,690	.....	318,760	280
All Other, Production	38,810	4,290	37,160	10,480	119,830	65,970
Transportation, Total	**547,502**	**47,520**	**389,801**	**42,710**	**1,419,482**	**195,210**
Pipe Lines, Total	400,402	42,040	284,701	25,530	837,882	100,940
Crude Oil Lines	281,330	40,750	163,050	15,060	531,110	100,530
Product Lines	71,590	.....	86,070	.....	222,390	.....
Natural Gas Lines	47,482	1,290	35,581	10,470	84,382	410
Marine, Total	119,890	5,360	47,330	16,610	435,210	91,090
Tankers	104,080	5,360	27,650	16,610	390,610	90,880
Barges	8,280	.....	10,910	.....	22,940	150
Others, Marine	7,530	.....	8,770	.....	21,660	60
Tank Cars	15,550	.....	20,210	.....	59,100	40
Motor Transport	7,500	.....	13,450	250	58,300	1,840
All Other, Transportation	4,160	120	24,110	320	28,990	1,300
Refining	**565,740**	**49,460**	**302,950**	**24,480**	**1,792,670**	**228,840**
Fertilizer and Chemical Plants	**66,350**	.....	**24,770**	.....	**113,790**	.....
Marketing	**288,950**	**38,860**	**267,690**	**25,700**	**1,091,710**	**118,310**
Other	**41,497**	**5,223**	**49,297**	**1,461**	**214,558**	**6,396**
GRAND TOTAL	**3,621,759 (4,085,762)**	**464,003**	**2,947,828 (3,270,959)**	**323,131**	**10,735,160 (12,377,046)**	**1,641,886**

* Figures on foreign capital expenditures include those made for consolidated subsidiaries only.

† Includes expenditures for intangible development cost of producing wells and dry holes whether capitalized or charged to earnings.

In terms of capital investment, the petroleum industry is considered the fourth largest in the country, according to the bank's report. The estimated $36 billion of gross assets employed by the entire industry in the U. S. at the end of 1951 consisted of these main components: fixed assets, 76 percent before deducting accumulated reserves; current assets, 22.5 percent; and other assets, 1.4 percent. (See Table 3.)

$27.4 Billion Investment

Gross fixed assets in the amount of $27.4 billion at end of 1951 represented the industry's investment in property, plant, and equipment, the Chase National pamphlet showed. Distribution by departments was as follows: production 56.8 percent, transportation 12.8 percent, refining 17.3 percent, marketing and others 13.1 percent. (See Table 4.)

Based on funds invested by 30 oil companies and other factors, the Coqueron report estimated that the capital expenditures by the entire petroleum industry in the U. S. aggregated $3.1 billion in 1951. This total was allocated as follows: production 68.5 percent, transportation 9.7 percent, refining 10.5 percent, marketing and others 11.3 percent. (See Table 4.) The capital outlay of the industry in the six postwar years, 1946-1951, amounted to approximately $15.4 billion, according to the Chase National Bank. Of this amount about 63 percent was utilized in expanding facilities for the production of crude oil, natural gas and natural gasoline.

TABLE 3

Estimated Assets Employed (Or Investment) in U. S. Petroleum Industry, December 31, 1951

(Source: Chase National Bank bulletin, "Financial Analysis of 30 Oil Companies for 1951")

ITEM	NET ASSETS		GROSS ASSETS	
	$ Million	Percent of Total	$ Million	Percent of Total
Current Assets	8,100	36.3	8,100	22.5
Investments and Advances	200	0.9	200	0.6
Property, Plant and Equipment	13,700	61.4	27,400	76.1
Other Assets	300	1.4	300	0.8
Total	22,300	100.0	36,000	100.0

TABLE 4

Property, Plant, and Equipment of U. S. Petroleum Industry

(Source: Chase National Bank Bulletin, "Financial Analysis of 30 Oil Companies for 1951")

DEPARTMENT	ESTIMATED EXPENDITURES FOR PROPERTY, PLANT, AND EQUIPMENT IN YEARS 1946-1951 — Million Dollars							6 Yrs., 1946-1951		ESTIMATED INVESTMENT DECEMBER 31, 1951, IN PROPERTY, PLANT AND EQUIPMENT — Gross		Net	
	1946	1947	1948	1949	1950	1951 $ Million	1951 Percent of Total	$ Million	Percent of Total	$ Million	Percent of Total	$ Million	Percent of Total
Production Department	**1,100**	**1,425**	**1,700**	**1,650**	**1,675**	**2,125**	**68.5**	**9,675**	**62.8**	**15,550**	**56.8**	**7,300**	**53.3**
*Oil Leases, Wells, Equipment	1,050	1,325	1,550	1,450	1,500	1,975	63.7	8,850	57.4	14,600	53.3	6,700	48.9
Natural Gasoline Plants	35	50	100	110	75	75	2.4	445	2.9	550	2.0	325	2.4
*†Natural Gas	15	50	50	90	100	75	2.4	380	2.5	400	1.5	275	2.0
Transportation Department	**170**	**310**	**325**	**270**	**175**	**300**	**9.7**	**1,550**	**10.1**	**3,500**	**12.8**	**1,875**	**13.7**
Crude Oil Pipe Lines	75	130	180	150	125	175	5.7	835	5.4	1,650	6.0	875	6.4
Product Pipe Lines	30	40	30	25	25	75	2.4	225	1.5	400	1.5	250	1.8
Marine	60	125	100	75	15	35	1.1	410	2.7	1,100	4.0	625	4.6
Tank Cars; Motor Trucks	5	15	15	20	10	15	0.5	80	0.5	350	1.3	125	0.9
Refining Department	**250**	**400**	**600**	**420**	**275**	**325**	**10.5**	**2,270**	**14.7**	**4,750**	**17.3**	**2,300**	**16.8**
Marketing Department	**200**	**300**	**225**	**240**	**275**	**300**	**9.7**	**1,540**	**10.0**	**3,200**	**11.6**	**1,950**	**14.2**
Others	**30**	**65**	**100**	**70**	**50**	**50**	**1.6**	**365**	**2.4**	**400**	**1.5**	**275**	**2.0**
Total, All Departments	**1,750**	**2,500**	**2,950**	**2,650**	**2,450**	**3,100**	**100.0**	**15,400**	**100.0**	**27,400**	**100.0**	**13,700**	**100.0**

* Expenditures include cost of drilling dry holes.

† Includes only natural gas producing, transmission and distribution facilities of oil companies.

News Notes On Refinery and Other Plant Construction

Petroleum Refiner's quarterly "Box Score" tabulation of projects appears next in the October issue

Engineering Progresses On Projected Arizona Refinery

Engineering is underway at Florence, Ariz., on an all-electric refinery which will cost about $18.3 million and whose products are designated for sale almost entirely within the state. Proven Oil and Refining Company has announced that Ebasco Corporation and Lummus Corporation are doing the engineering work on the 15,000-barrel-a-day refinery. Construction contracts have not been let.

L. M. Glasco is president of Proven Oil and Refining Company, a recent company organized to build and operate this projected plant. Other officers are: Bert Hull, chairman of the board; John B. Mills, vice president; and Ray Hubbard, secretary-treasurer.

Albania To Build Refinery Of 3000-Barrels-Daily Size

Construction is scheduled to start soon at Cerrid, Albania, southwest of Elbasan, on a 3000-barrel-per-day refinery designed to meet the national requirements of the country, the Albanian government has reported.

Watson, Calif., Refinery Slated for Huge Expansion

Richfield Oil Corporation has announced it is ready to begin a $40 million refinery expansion which will increase the crude capacity of its Watson refinery, near Long Beach, by 20,000 barrels a day. In addition aviation gasoline production will be increased to 12,000 barrels daily and total gasoline output increased by more than 40 percent. Facilities for ethylene recovery and conversion of propylene to gasoline are new features being added to production units.

Engineering plans call for incorporation of proper air pollution control devices. This project, already authorized by proper governmental agencies, is scheduled for completion in 1954.

Sunray Reactivating Plant

Sunray Oil Corporation has announced that it is starting reactivation of its World War II alkylation plant, which will become an integral part of the Sunray (Duncan), Okla., catalytic cracking refinery, whereby the company expects to be in a position to produce aviation gasoline stock by March, 1953.

PROPANE DEASPHALTER FOR ENGLAND—Under construction by The Kellogg International Corporation, this will be England's first propane deasphalter, according to The M. W. Kellogg Company, New York, engineer-contractors. It was designed for Anglo-Iranian Oil Company, Ltd.'s new refinery at Kent, England, and will have a fresh feed capacity of 4500 barrels per day. Shown in the foreground is the steelwork for an "A" frame heater. The main tower, strippers and secondary fractionator are already in place, as are a number of the heat exchangers.

Fluor Awarded Major Portion Of Regina Refinery Expansion

Contract for the major portion of a $7 million modernization program at Imperial Oil's Regina refinery has been let to the Fluor Corporation. R. W. Dunlop, manager of the engineering division of Imperial's manufacturing department, announced the contract award and said that Fluor plans to sub-contract a considerable portion of the work to western Canadian firms.

Plant construction is expected to begin late this year and be completed by the spring of 1954. Clearing and preparation of the site has started.

The contract includes the building of a 7500-barrel-per-day fluid catalytic cracking unit, a vacuum distillation unit with a 9000 barrel daily capacity, and a light ends plant for the recovery of gases. The program will raise the refinery capacity from 20,000 to 22,500 barrels a day.

Houdriflow Unit To Be Installed At Antwerp Plant

Houdry Process Corporation and their foreign representatives, World Commerce Corporation, S.A., have announced that Albatros S.A. Belge pour le Raffinage de Petrole will install a Houdriflow catalytic cracking unit at their Antwerp, Belgium, refinery. The moving-bed installation, employing a gas-lift for catalyst circulation, is designed for a nominal capacity of 3600 barrels per day.

The agreements just concluded for the expansion and modernization of the Antwerp refinery also call for a feed preparation unit, a gas recovery and stabilization unit, a plant for the polymerization of light olefins produced in the cracking operations, and new facilities for treating straight-run and catalytic gasolines.

Petrocarbon, Ltd., are consultants to Albatros. Drafting, engineering and procurement are being handled by Head Wrightson Processes Ltd., of London.

ASPPA, Globe Sign Contract For New Alkylate Plant

Armed Services Petroleum Purchasing Agency has executed its second contract in its aviation alkylate expansion program for a 1500 barrel-per-day plant to be built and operated by Globe Oil Refining Company at Lemon, Ill. ASPPA has reported that three more contract negotiations are nearing the final stage, with signing of one of these "expected momentarily."

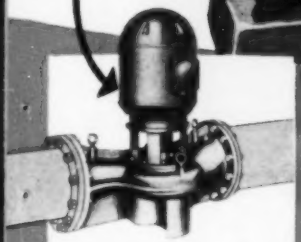
The first contract signed was with Eastern States Petroleum Company of Houston, calling for rehabilitation of existing but non-operative facilities in the Houston area.

Chemico Awarded Contract For Lion Chemical Plant

Lion Oil Company has let contracts covering the design and construction of its new Barton chemical plant to be constructed at Luling, La., to Chemical Construction Corporation. The Lummus Company will be the prime contractor for construction.

The new plant will be located on a 1400-acre site on the west bank of the Mississippi River in St. Charles parish about 14 miles upstream from New

Cosden's "poly plant" charge pumping unit is compact and highly efficient. 1750 RPM from 50 HP electric motor is reduced by gear unit to 438 pinion shaft RPM of pump, providing more than adequate HP input to deliver 110 GPM at 600 psi.



"IN-LINE" centrifugal booster pump with capacity to handle 110 GPM of .52 specific gravity liquid and develop sufficient net positive suction head for Triplex pump to prevent vapor-lock.

WILSON-SNYDER REFINERY PUMPS...

handle the Butane-Propane Charge for the "Poly Plant" at Cosden's Big Springs, Texas Refinery

THE PUMPING PROBLEM—To handle the charge for the polymerization unit in Cosden's recently completed fluid "cat" cracker, requiring 110 GPM of a volatile butane-propane mixture at 110-degree F, with suction pressures approximating 50 PSI to be discharged at 600 PSI and to operate under continuous service conditions.

Mr. E. B. McCormick, Chief Engineer for Cosden Petroleum Corporation SOLVED THE PROBLEM by installing . . .

. . . a pumping unit consisting of a Wilson-Snyder Vertical "In-Line" Centrifugal Booster Pump with 7½ HP direct-connected motor, attached directly to the suction flange of a Wilson-Snyder No. 46-P (size 4½" x 6") Horizontal Triplex Single Acting Plunger Pump driven by a 50 HP motor through a gear reduction unit. The Triplex Pump is equipped with forced-feed plunger lubrication and hardened stainless steel plungers and valve service. This pump has a rated maximum capacity of 174 GPM at 140 RPM to develop 630 PSI discharge, therefore this application (110 GPM at 98.5 RPM with 600 PSI discharge pressure) is well within the pump's range and follows good engineering practice.

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CONTRACT # 14839

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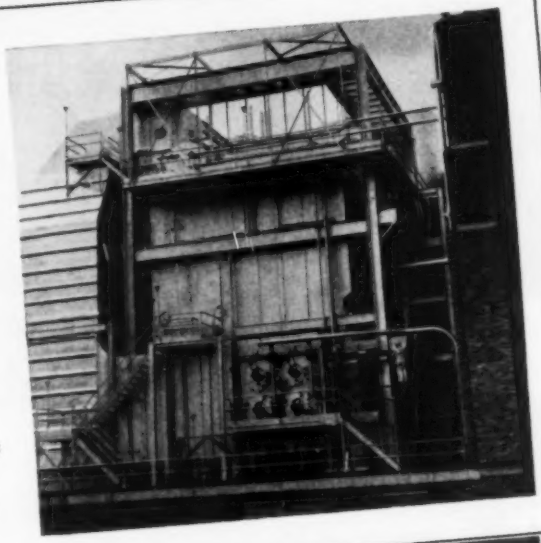
Weleetka Power Station,
Weleetka, Oklahoma.

INSTALLATION:
Babcock & Wilcox water wall boiler — gas, oil, or coal-fired — steam output=330,000 lbs./hr.

OPERATING TEMPERATURE:
835° F. — steam pressure 700 lbs.

REMARKS:
Outdoor location requires efficient insulation. Insulation on breeching must be weatherproofed.



Outdoor boiler suspended in air cuts installation costs

By suspending this boiler in air, the Public Service Company of Oklahoma, greatly reduced the cost of foundation footings, saved appreciably on construction costs. The suspension method also relieved the problems caused by expansion and contraction of boiler sidewalls.

This photo shows part of the supporting steelwork, as well as the breeching (left), and the spring loaded hangers that carry the main steam header.

To boost efficiency and cut operating costs, all major elements of this outdoor boiler were insulated by Armstrong's contracting organization. A 2" layer of Hy-Temp block was used on the boiler front wall, while the furnace front wall was insulated with 4" of Hy-Temp block. Insulation of both walls is covered with a metal casing bolted to the boiler proper. The breeching was insulated with 2½" of 85% Magnesia block and weatherproofed with Armstrong's Insulmastic.

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3. Technical ability — experience, plus technical and research staff to complete the work in accordance with best practices.
4. Manpower resources — trained supervisors and workmen able to handle any contract efficiently.
5. Efficiency—ability to handle accurately things like accounting, tax provisions, insurance, and workmen's compensation.

You get all these with an Armstrong Contract

ARMSTRONG'S INDUSTRIAL INSULATIONS

Orleans. It will consist mainly of outdoor type process units with modern one- and two-story buildings for administration, maintenance, warehousing and employe services. Unless construction is delayed, the new facility is expected to begin operation early in 1954.

Products to be manufactured include anhydrous ammonia and prilled ammonium nitrate. Nitric acid will be produced in an intermediate step. Natural gas for process material and fuel will be supplied by The Texas Company from nearby fields.

MOR Begins Expansion of Lubricating Oil Facilities

A site has been cleared and construction started on new facilities for Manchester Oil Refinery, Ltd., which will increase its capacity to produce lubricating oils, white oils and transformer oils to about 3000 barrels per day. The crude thruput in 1951 averaged about 2375 barrels daily. The expansion program, which includes new atmospheric distillation units, is scheduled for completion in November.

Empire Refinery, Denver, Builds 5000-Barrel Capacity

Capacity expansion from 1500 to 5000 barrels daily has been announced for the Empire Petroleum Company refinery in Denver, at a cost of $50 million. In addition the company plans to develop its own crude production. Empire is under contract to Bay Petroleum Corporation to deliver 850 barrels of refinery product daily.

Dunkirk Lubricating Oil Plant Now in Operation

The lubricating oil plant at Dunkirk refinery, operated by Anglo-Iranian Oil Company's French associates, the Societe Generale des Huiles de Petrole BP, is now in operation. The plant, which has a capacity of 16,500,000 gallons per year, will supply the French and North African markets of the S.H.H.P. and the balance will be exported to other Continental markets including Belgium, Holland and Switzerland.

Contract For New Australian Plant Awarded To C. F. Braun

Standard-Vacuum Oil Company has awarded to C. F. Braun & Company the engineering and construction contract for its new 20,000 barrels-per-day crude oil refinery to be built at Altona, near Melbourne, Australia, by its new subsidiary, Standard-Vacuum Refining Company, Pty., Ltd.

The new refinery will adjoin the present 1600 barrels-per-day lubricating oil and asphalt plant which up to now has been operated by Stanvac's marketing subsidiary in Australia. The new installation will include catalytic cracking equipment, a crude topping unit, reforming facilities, light products treating equipment and a steam-generating plant.

California Standard Buys Site For Future Refinery

Standard Oil Company of California has announced the purchase of about 2000 acres of land in Snohomish County, Wash., as a possible site for future construction of an oil refinery.

The site is southwest of Paine Field, 20 miles north of Seattle. President T. S. Petersen said, "Our company hasn't any plans of any kind now for the use of this tract. However, the way the Pacific Northwest is growing, both in population and industry, indicates to us that sooner or later it may be desirable to build a refinery there to take care of the expansion of our business."

Anglo-Iranian's Antwerp Plant Officially Opened

The Prime Minister of Belgium, M. Van Houtte, has officially opened the new 40,000 barrels-per-day refinery built at Antwerp by the Compagnie Financiere Belge des Petroles S.A. (Petrofina) and the Anglo-Iranian Oil Company. The ceremony was attended by several hundred leading members of the Belgian industrial and commercial community as well as by members of the Belgian government. The cost of the new plant, which went on stream last October, is about $28 million. Output this year is expected to reach 30,000 barrels daily.

Construction

Dow Chemical Announces Plans for Ethylene Plant

Dow Chemical Company, who recently completed a $3,480,000 butadiene plant, has announced plans for building a $6,675,000 ethylene plant at Freeport, Texas. The two Dow projects are part of a $175-million expansion program announced in May and scheduled for completion in 1954. No work has started on the ethylene plant which was allowed a 50 percent tax write-off on the bulk of the project and 25 percent on the rest. The butadiene plant has been completed and is in operation.

Turkey Will Build New 5400 Barrel-Per-Day Refinery

The Turkish parliament has learned from its Prime Minister that the government has reached an agreement with a United States firm on the construction of a refinery in the country. The refinery will be located at Batman, near Ramandag, and is scheduled for operation by mid-1954 with a capacity of about 5400 barrels per day.

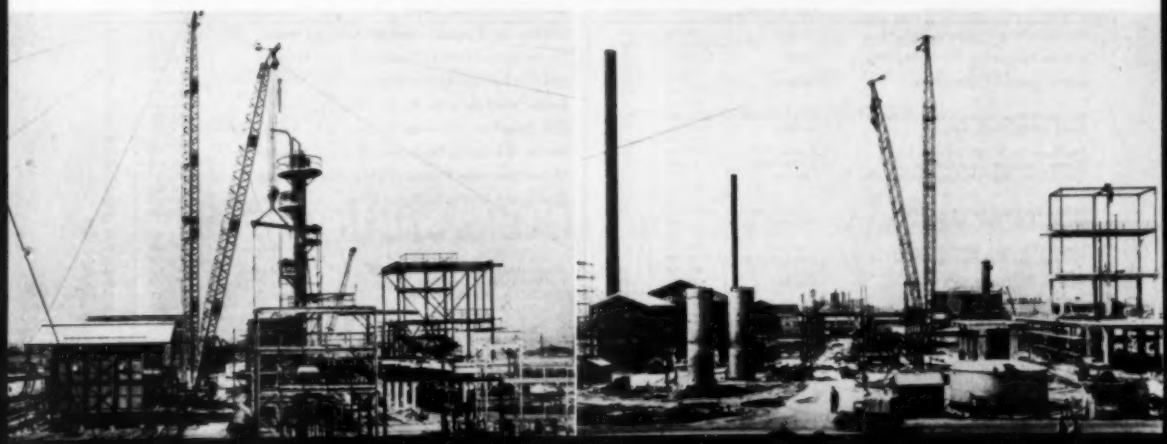
Products will include 35,000 tons per year of gasoline, 29,000 tons of gas oil, 10,000 tons of diesel oil, 37,500 tons of asphalt and 130,000 tons of fuel oil.

Refinery, Gas Plant To Be Constructed In Colombia

The Bogota representative of the Colombian Petroleum Company has stated that the company plans to start construction later this year of a plant to treat the wet gas produced at its Barco Concession. The plant will be designed to process one million cubic feet of gas daily. It is expected that the plant will produce 1500 barrels of natural gasoline and butane, which will be used to stabilize the gasoline produced in its refinery and to mix with the crude that it exports. It is estimated that the plant will cost $5 million.

Also to be constructed along with the gas plant will be a new refinery, con-

CORYTON PROGRESS—Construction is progressing rapidly at Vacuum Oil Company, Ltd.'s Coryton, England, refinery as is evidenced by these progress photos of the crude distillation unit, above left, and the furfural unit, right. The complete refinery will consist of a two-stage crude distillation unit, a TCC unit, thermal reformer and motor spirit treating plant, propane deasphalter, furfural treating, MEK dewaxing and clay contacting facilities. The $40-million refinery is located 20 miles from London on the Thames River estuary.



sisting of a simple topping unit of 2000 barrels daily capacity. The refinery will be located at the Tibu Field and will replace the present 1000 barrels-per-day installation located at Petrolea.

DPA Write-Off Rules Now Require Local Approval

Defense Production Administration in a revision of its regulations for applications for certificates of necessity for rapid tax amortization, is now requiring approval of local industrial dispersion groups as to sites for proposed facilities to accompany most applications.

More than 60 local dispersion groups have been formed for the purpose of making preliminary studies and recommendations concerning comparative target security of proposed plants. The principal considerations to be used by these groups in recommending plant sites are:

1. Industrial development areas should be 10 to 20 miles from any densely populated or highly industrial sections of an urban area. This dispersal distance may be less when additional protection is provided by rugged topography or protective construction.

2. These areas should be 10 to 20 miles from prime targets like major military installations.

3. They should be sufficient distance from one another to avoid clusters, creating new targets.

4. They should be limited in size to avoid concentrations which would create new targets.

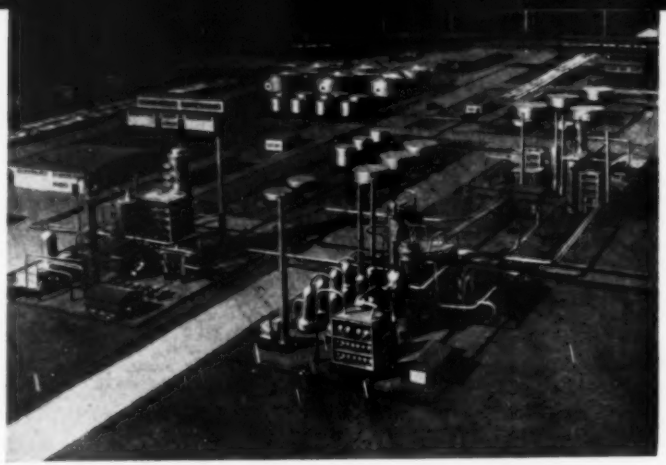
5. The sites, desirably, should be served by more than one transportation facility to insure continued production and distribution.

6. The sites, desirably, should be on power and other utility grids to permit alternate sources.

7. Other standards based on local conditions should be considered.

Application of these methods to the petroleum refining industry would be to discourage approval of rapid tax amortization certificates for additional construction of plants in highly concentrated refining centers.

The accompanying list is chiefly comprised of those projects for which approval was granted June 6-July 2.



ITALIAN REFINERY—Shown above is a scale model of Soceita per Azioni Raffineria Padana Olii Mineral's 13,000 barrel-per-day refinery, owned jointly by the Fiat Company and the Caltex group. The plant, located at San Martino di Trecate, Italy, is expected to go on stream sometime in October. It will be supplied with crude oil from the Mediterranean terminal at Savona via pipeline.

Humble Planning $5 Million Gasoline Project in Texas

Humble Oil & Refining Company is planning a $5-million gasoline project at Baytown, Texas. The project is a propane deasphalting plant which will extract feed stock from fuel oil for the Baytown cat cracker. The plant is not in construction and negotiations are underway to line up contractors for the project. The plant will take between 18 months and two years to complete.

Lukuga Synthetics Plant Possibility For Congo

The possibility of establishing a synthetic oil plant in the Belgian Congo by the Lukuga Coal Syndicate has already passed the study stage, according to the Belgian press. The syndicate has shipped several hundred tons of coal from the Lukuga Basin to Belgium for testing to determine its adaptability for transformation into gas, and to choose the most appropriate method of gasification.

The Lukuga Coal Syndicate was organized in 1950 to study the possibility of establishing a synthetic fuels plant in the Belgian Congo. The Congo has coal deposits but no known oil resources.

California Petrochemical Plant Certified By DPA

Design and engineering work are underway and Certificates of Necessity have been issued by the Defense Production Administration, for a new plant in Los Angeles county, Calif., for Carbide and Carbon Chemicals Company. The company, which is a division of Union Carbide and Carbon Corporation, plans at this new plant to produce polyethylene. The plant also will produce ethylene glycol. The project, according to the Certificates of Necessity, will involve an eventual investment of upwards of $36 million. It is being designed to produce from 50 to 60 million pounds of polyethylene and from 5 to 10 million gallons of ethylene glycol a year.

Burmah Oil and Shell May Build New Plant at Bombay

Burmah Oil Company's chairman, Sir Kenneth Harper, has told shareholders that the company proposes to build a new refinery at Bombay, India, in conjunction with Shell Oil Company. Burmah's share of the cost was estimated at $25,200,000. The company's expansion program, Harper also said, may amount to between $56-70 million in 5 years.

Fast Tax Writeoffs Certified by Defense Production Administration

COMPANY AND LOCATION	Type of Facility	Amount Amortization Certified	Percent Allowed
Sinclair Refining Co., Marcus Hook, Pa.	Gasoline	150,000	45
		820,000	65
Lakeside Refining Co., Kalamazoo, Mich.	Gasoline	1,218,000	65
		205,000	40
Aurora Gasoline Co., Elsie, Mich.	Gasoline	850,000	65
		178,000	45
		62,000	15
National Petrol-Chemicals Corp., Tuscola, Ill.	Ethyl Chloride	4,515,950	65
Husky Oil Co., Cody, Wyo.	Gasoline	1,662,700	65
		144,000	50
The Texas Co., St. Mary Parish, La.	Natural Gas	429,400	50
Warren Petroleum Corp., Lindsay, Okla.	Natural Gas	83,856	25
Cotton Valley Solvents, Inc., Cotton Valley, La.	Gasoline	111,850	65
		272,993	40
		18,548	15
Phillips Petroleum Co., West, Tex.	Natural Gasoline	830,400	25
The Texas Co., Port Arthur, Tex.	Gasoline	383,000	50
		1,847,000	65
Lion Oil Co., et al, Scurry Co., Tex.	Gasoline	545,729	65
Pan American Refining Corp., Texas City, Tex.	Gasoline	2,128,000	90
		567,000	50
Shell Oil Co., Dillard, Okla.	Gasoline	45,100	39
		130,000	40
		16,100	50
		187,800	65

COMPANY AND LOCATION	Type of Facility	Amount Amortization Certified	Percent Allowed
McKamie Gas Cleaning Co., Magnolia, Ark.	Propane	40,000	40
		75,000	65
Pan-Am Southern Corp., El Dorado, Ark.	Gasoline	145,000	65
	Refining	35,000	50
Shell Chemical Corp., Deer Park, Tex.	Ethylene-Propylene	227,330	50
		1,214,570	75
Humble Oil & Refining Co., Baytown, Tex.	Gasoline	1,415,000	50
		835,000	25
J. M. Nubor Corp., Hutchinson Co., Tex.	Natura Riasoline	8,730	40
		55,200	65
Humble Oil & Refining Co., Baytown, Tex.	Gasoline	4,100,000	65
		900,000	50
Midland Cooperative Wholesale, Cushing, Okla.	Gasoline	2,496,056	65
		734,622	45
Humble Oil & Refining Co., Baytown, Tex.	Propylene, Butylenes and Butanes	550,000	50
		3,650,000	65
Esso Standard Oil Co., Baton Rouge, La.	Petroleum Products	710,000	15
		4,925,000	40
		16,070,000	65
Sunray Oil Corp. (operator) Snyder, Tex.	Gasoline	1,004,500	65
Phillips Pipe Line Co., West, Tex.	Natural Gasoline	252,900	25
Shell Oil Co., Wilmington, Calif.	Gasoline	325,000	65
		1,175,000	45
		5,500,000	25

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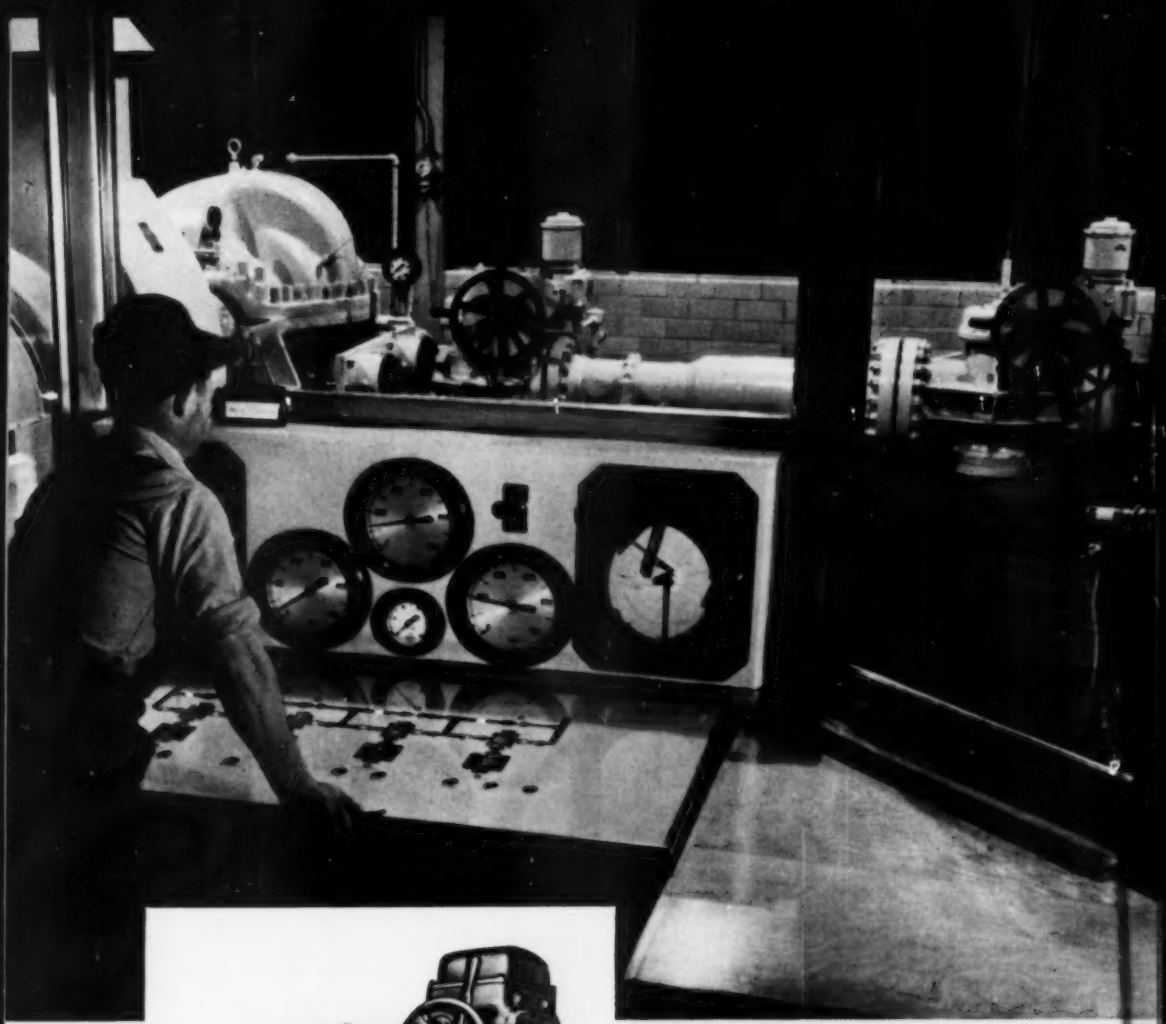

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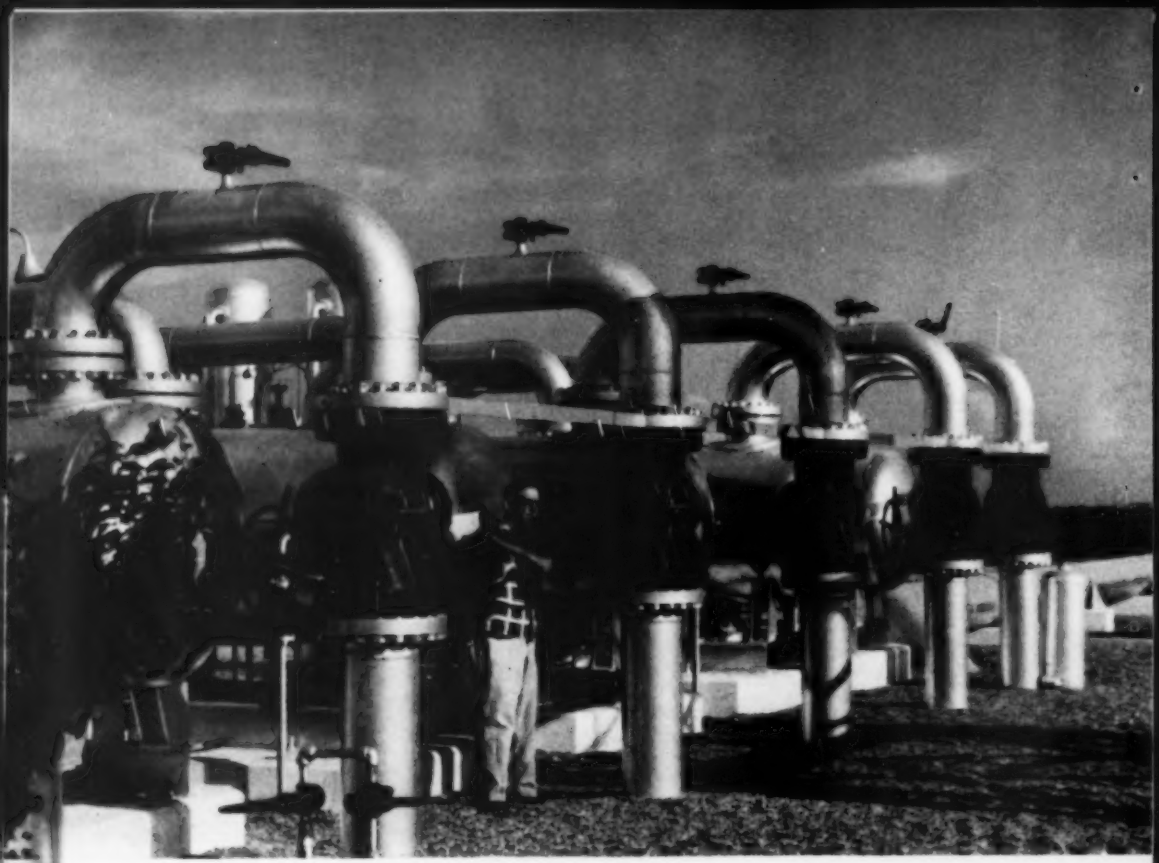

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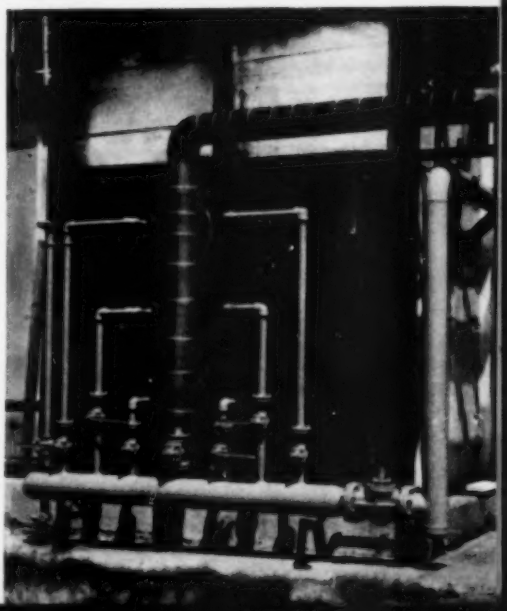

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LUBRICANT SEALED TO KEEP UPKEEP DOWN

Dehydration of Natural Gas And Light Hydrocarbon Liquids

Part I—Principles of Dehydration

JOHN M. CAMPBELL and LAWTON L. LAURENCE
Black, Sivalls & Bryson, Inc., Oklahoma City

THE rapid growth of the natural gas industry in the last decade has increased the necessity for providing adequate dehydration facilities, both in the field gathering systems and the long transmission lines. With this growth old existing methods have been modified and improved, and new methods developed. Many of these new methods have been encouraged by the increasing economic importance of the condensate products obtained from these natural gas systems. In many instances the recovery of a stable condensate can result in a larger monetary return than from the natural gas itself, even though the price of this latter commodity is always increasing.

With the choice of dehydration equipment that now exists it is necessary to consider the economic and process factors involved with each in order to procure the best equipment for the job. Past experience has shown that each method has definite limitations and that no one type is best suited for all jobs.

This series of articles has been written to consolidate and review the existing knowledge of dehydration and to serve as a guide for the design and choice of dehydration equipment. The major portion of the discussion involves the dehydration of natural gas specifically although many of the factors apply to other gases. The dehydration of liquids is also included since it is an integral part of the overall dehydration picture in the petroleum industry.

This article, the first of a series, will be limited to a basic discussion of the mechanics of dehydration. Subsequent discussions will deal with the economic and operational factors of the various systems including dry and liquid desiccant absorption systems, expansion refrigeration systems, injection of inhibitors, and dehydration of light hydrocarbon liquids.

A large amount of work has been reported in the literature, particularly with regard to dry desiccant adsorption systems. The accompanying bibliography includes most of these, for the convenience of those investigating dehydration problems. Space limitations prohibit citing of all references; so only those are cited which apply specifically to the factors discussed in each of the systems.

Dehydration Methods

The water vapor content of a gas may be reduced by any one, or a combination, of four basic methods:

1) Compression to a higher pressure with subsequent cooling.
2) Cooling below initial dewpoint.
3) Adsorption with dry desiccants.
4) Absorption with liquids.

Any of these methods may be used to dry gas to the desired specifications but there are limitations in practice imposed by process and economic factors.

Regardless of the method used, the driving force causing the vapor to leave the gas and condense must be larger than that force which tends to make the liquid vaporize. Any method of dehydration then is simply a means of either reducing the vaporization tendency or increasing the driving force causing condensation of the water vapor. With any system, at a given temperature and pressure, an equilibrium will eventually be reached. When such a condition exists water is vaporizing at the same rate as it is condensing, and there is no change in the water content of the gas with time. In commercial equipment this equilibrium can be approached, but is never reached. However, the concept of equilibrium is a convenient means of analyzing and explaining the mechanisms of dehydration.

The relationship between the amount of water in the gaseous phase and liquid phases may be expressed by Raoults Law

$$Py = px \qquad (1)$$

or by a vaporization equilibrium constant

$$y = Kx \qquad (2)$$

where: P = total pressure in the system
y = mol fraction of water vapor in the gas.
p = Vapor pressure of the liquid water at its temperature in the system.
x = mol fraction of the water in the liquid phase.
K = vaporization equilibrium constant for water in a given system, at the given system's temperature and pressure.

Equation (1) gives erroneous values when applied to gases at high pressure but is convenient to use in discussing basic concepts. Equation (2) gives more exact values, where K may be determined experimentally or calculated from fugacities. At this time, however, K values for water have not been published for many systems, and it is necessary to revert to Equation (1) or some modification of it, in many instances. Active work is now being undertaken to determine more K values and they should be used when available. Equation (1) will suffice, however, for a discussion of the four systems outlined above.

Compression

The effect of compression on the water content of a gas may be easily seen by reference to a water content chart such as shown in Figure 1, which is an enlarged section of a chart covering a larger range (89). For example, if natural gas at 80° F. and 100 psia is compressed to 300 psia and then cooled back to 80° F. in an after cooler, about 63 percent of the water in the original gas will condense out as liquid.

This same effect may be illustrated by the application of Equation (1). The vapor pressure p, which is a function of temperature only, is the same initially and finally while x remains equal to one, for all practical purposes. Therefore, in the compression process used the right hand side of Equation (1) is constant. Consequently then, as the total pressure P is increased the fraction of water y must decrease accordingly to maintain the equality of

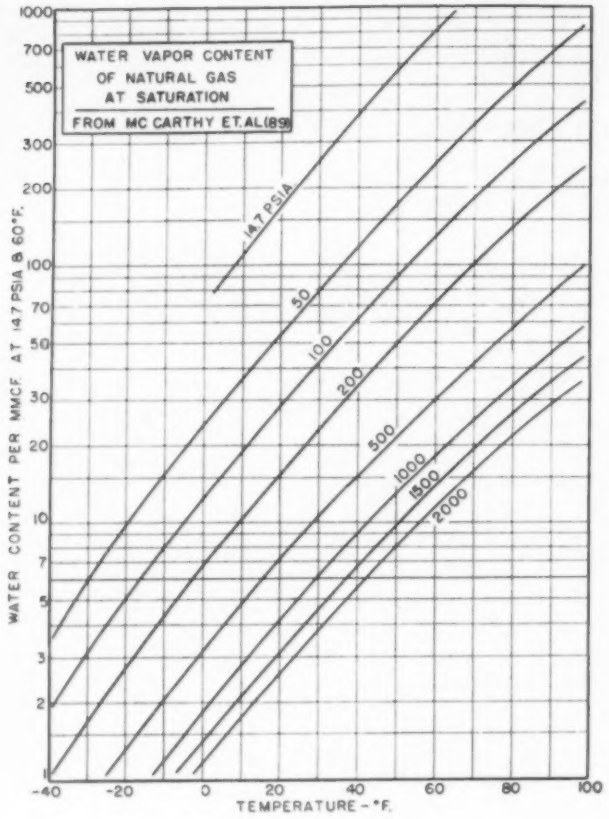

Figure 1.

the equation. The same thing might be illustrated with Equation (2) since the value of K decreases with an increase in pressure, at constant temperature.

The use of compression, however, as an effective means of dehydration is limited. The amount of compression required is governed by factors other than dehydration, and the accompanying dehydration, for a given compression ratio, is not always sufficient. In addition the amount of water condensing in the inter and after-coolers requires a large cooling capacity due to the latent heat of the water. In many instances it is cheaper to dry the gas, at least partially, before compression, than have this additional cooling cost. Because of the high initial and operating cost other methods are usually used.

Cooling

As shown in Figure 1, the cooling of a gas will also reduce the water content. Several means of cooling are used, depending on the degree of dehydration needed:

1) Spray cooling.
2) Surface condensers.
3) Refrigeration coils.
4) Expansion refrigeration.

Spray cooling is normally used to dehumidify air at atmospheric pressure and is rather uncommon in the natural gas industry. In this system water, colder than the gas, is sprayed through nozzles to contact the gas and subsequently cool it.

With such a system using cooling tower water, an exit gas temperature lower than 85-90° F. cannot usually be obtained in most localities. For lower temperatures refrigerated water is necessary. Water may be refrigerated for this purpose by a) a steam ejection system, b) absorption refrigeration or c) compression refrigeration.

Methods 2 and 3, above, are actually the same system, depending only on the temperature of the coolant involved. The term surface condenser is normally applied to those systems where the cooling medium is water from a cooling tower whereas the latter is used when the cooling is accomplished by a refrigerant. In either case the water from the gas condenses on the outside of the heat exchanger and runs off. When coils are used with refrigeration, however, it is necessary to shut down occasionally and defrost. In some processes this is minimized by spraying an anti-freeze on the coils.

Method 4, more commonly called low-temperature separation, finds wide application with natural gas because of the gasoline recovery in addition to dehydration. The cooling on expansion is based on a thermodynamic law attributed to Joule and Thomson who have defined, by means of a coefficient, the temperature drop to be expected during this expansion if no heat is lost to the surroundings. Such an equation, while not giving exact results under actual process conditions, does give the order of magnitude of the drop to be expected. A discussion of the process factors and field data will be included in Parts IV and V of this series.

Regardless of the mechanism of the cooling, the thermodynamics of drying may also be illustrated by the application of Equations (1) and (2). For example, if a gas at constant pressure is cooled the vapor pressure (p) of the liquid is reduced, while the value of (x) remains equal to one. Since the right hand side of the equation is thus reduced, and the total pressure P is substantially constant, the fraction of water vapor in the gas, y, must be smaller to maintain the equation's equality. Equation (2) also shows the same relationship since the equilibrium constant K is proportional to the temperature, at constant pressure.

Adsorption

The exact mechanisms by which adsorption takes place is difficult, if not impossible, to define. Numerous theories have been advanced, none of which can be definitely proven. However, definite surface forces exist on a dry desiccant which tend to hold the water as a liquid and reduce its effective vapor pressure. The word surface, as used in adsorption, refers not only to the outer portion of the granule but the large surface represented by the internal pores of this granule. This internal porosity is a necessary essential of any desiccant since adsorption is purely a surface phenomenom and most of the area of any particle is represented by the walls of these small internal pores. It has been established, for example, that one of the gel type desiccants presents a surface area of more than two million square feet per

pound, almost all of which is represented by the wall area of the internal pores.[135]

A true adsorption process does not involve a chemical reaction for it often takes place with elements or compounds which are considered chemically inert. It is sometimes assumed that some valences holding the atoms together are free at the surface. These secondary valences represent an unstable situation and an attempt is made to find atoms to become stable. This force may account for the adsorptive properties of various materials. Once the magnitude of these forces may be determined quantitatively, it will be possible to more fully evaluate their effect.

The large number of small pores which must be present to give such a tremendous amount of surface introduces the possibility that they act to reduce the vapor pressure of the water, for it has long been known that any liquid in a small capillary exhibits an abnormally low vapor pressure due to surface tension effects. There is evidence to indicate that these pores have constricted necks and/or are open pores which widen out toward their base. Such construction may be predicted by the fact that the adsorption-desorption curves do not coincide. During adsorption the vapor pressure of the water is determined by condensation in the larger section whereas during desorption, or regeneration, it is determined by the constriction.

The most common method of plotting adsorption curves is to use the amount adsorbed per unit weight of desiccant as the ordinate and the concentration of water in the gas as the abscissa. Such a plot results in curves which are concave with respect to the abscissa, each such curve representing a given temperature. The curves vary with the gas and the desiccant but usually have the characteristic shape shown in Figure 2.

A number of exponential equations have been developed in an attempt to predict the experimental curves obtained. The Freundlich equation

$$x' = kc^n \qquad (3)$$

where: x' = wt. of water adsorbed per unit wt. of desiccant

c = concentration of water in the gas, k & n are arbitrary constants

says that a log-log plot of x' vs. c would be a straight line with slope n and intercept k. Therefore, it usually only applies for certain systems of materials in a limited concentration range.

A more general equation is that attributed to Schmidt, of the form

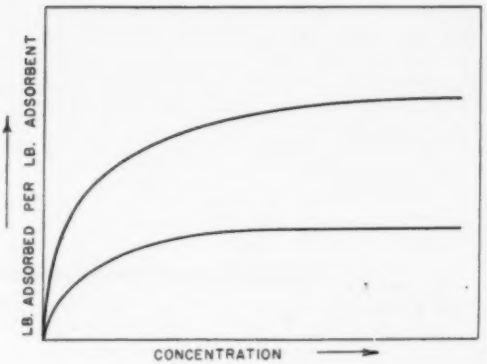

Figure 2. Typical Adsorption Curves For Dry Dessicants.

$$xe^{A(c-s^2)cs'} = kcs. \qquad (4)$$

where: A = arbitrary constant

c = base of the natural logarithm.

s = wt. of water adsorbed per unit wt. of desiccant, at saturation.

Equations (3) and (4), which are purely empirical, may only be used when specific data are available for a given system of materials under specified conditions. Consequently their application is somewhat limited due to the scarcity of detailed experimental data.

Regardless of the mechanism of adsorption the dehydration is accomplished, with reference to Equation (1), by lowering the vapor pressure (p) of the liquid water below that which is normal at a given temperature and pressure.

Due at least partially to this lack of detailed theoretical information the processing engineer is primarily concerned with those factors influencing the type of desiccant used and the overall design criterion set up. These factors are discussed in some detail in Part II of this series. The available information on the most common types of commercial desiccants has been tabulated for reference. All solids adsorb water to some extent but their efficiency varies with the nature of the material and its internal porosity. In most instances some form of an activated alumina or a gel type desiccant is used.

Absorption

The dehydration of gas with liquid absorbents usually represents one of the simplest applications of absorption. Only one component is removed in any quantity which simplifies the theoretical approaches to the problem. The amount of water in natural gas at saturation is small, percentage wise, which even further simplifies any necessary calculations.

If the gas and liquid are allowed to come to equilibrium the fraction of water in the gas is a direct function of the fraction of water in the liquid phase. This is shown by Equations (1) and (2), for at constant temperature and pressure the values of P, p and K are fixed. However, equilibrium is never reached in commercial processes so it is more important to have a means of predicting the rate at which water is absorbed. Water is highly soluble in any commercial liquid desiccant used so it is necessary in determining rates of absorption to examine those physical factors which hinder the absorption from taking place. The rate of absorption, like adsorption, depends on the surface presented; thus the main resistance must be concentrated at the interface, or the surface of contact between the gas and liquid. Due to molecular action, convection currents are present in any fluid and the main body is invariably in motion with respect to this interface. Consequently there are what might be called double "films" at the surface, one in the gas phase and one in the liquid adjoining the interface.

As represented in Figure 3, there is a higher concentration of water at the interface than in the remainder of the fluid. Before the water vapor can be absorbed it must diffuse through these two barriers. The driving forces to overcome this are the partial pressure difference in the gas and the concentration difference in the liquid. One of these films, as with heat transfer, is normally controlling. If the material to be absorbed can leave the gas faster than it can be dissolved and carried away by the convection currents, the liquid film is said to control. In the opposite case, for very soluble gases, the gas film is the controlling factor. The chief resistance is then the concentration of water vapor molecules adjacent to the interface.

In dehydration the liquid film offers little resistance compared with the gas

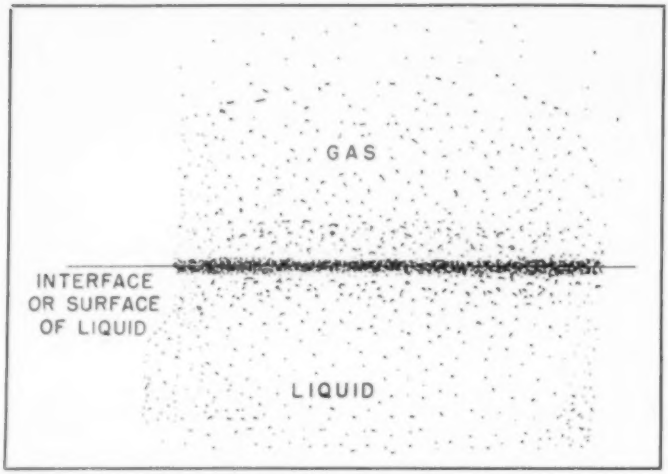

Figure 3. Representation of the Relative Water Concentration in the Gas and the Liquid.

film because water is normally very soluble in the liquid desiccant and no concentration of water builds up at the surface. The gas film is therefore the main controlling factor for the rate of absorption.

Even though such a film might not actually exist in say a bubble tray tower, this film concept has been a great aid in visualizing the absorption process. It lends itself particularly to mathematical analysis and a number of diffusion film coefficients have been experimentally determined. The knowledge of such values expedites a more exact design for liquid absorption equipment.

From a pure process viewpoint the amount of water that may be removed by a given liquid from a gas depends on:

1) Temperature and Pressure of the system.
2) Amount of contact between the liquid and gas (height and design of the absorber).
3) Concentration of water in liquid desiccant.
4) Circulation rate of the liquid desiccant.
5) Temperature and viscosity of liquid desiccant.

These and other process factors are discussed in some detail in Part III of this series.

Gas Hydrates

Most natural gas is dehydrated to prevent the formation of natural gas hydrates. Although these hydrates have a different crystalline structure than common ice the effect is the same when they form and plug a line. Their temperature of formation bears no relationship to the freezing point of water and depends primarily on the pressure and composition of the gas.

Gas hydrates were discovered as early as 1810 but Hammerschmidt did the pioneer work on natural gas systems. He and other investigators found that a methane hydrate was the easiest to form, with the difficulty of formation increasing with an increase in molecular weight. A normal butane hydrate, at best, is difficult to form and hold.

Since these hydrates are stable only at high pressures, research in the field has been hindered and only partial information is available about many phases of their characteristics. In addition, their formation is influenced by the physical characteristics of the system which means that laboratory data do not always apply in the field. It has been determined, however, what compounds form hydrates and those factors that influence this formation. Many of these data for pure gases do not apply to natural gas, however, due to its varying composition.

For a given gas though the temperature at which hydrates appear is a function of pressure. Figure 4, based on work of Katz et al.[76] may be used to predict the temperature of formation, for a given pressure. This curve shows a slightly higher hydrate point than some other data but the small safety factor involved makes it ideal for use in the design and operation of field equipment. Other data by Katz,[77] for example, show that the hydrate point for 0.6 to 0.7 specific gravity gas is about 3-8° F. below that shown. However, the ease with which hydrates form depends also on such physical factors as the degree of gas turbulence, the presence of liquid water and the construction details of the system. Consequently no general correlation will give reliable results for all systems. This curve though has been found safe to use for the majority of cases.

Hammerschmidt[59] has developed an equation

$$t_H = 8.9P^{0.285}$$

where P = absolute pressure — psia.
t_H = hydrate formation temperature — °F.

A plot of Equation (5) on Figure 4 would give a curve substantially parallel to that shown and predict temperatures about 5-7° F. lower. It would correspond roughly to the data shown by Katz for a 0.6 to 0.7 specific gravity natural gas. Various field checks have shown Equation (5) to be reasonably accurate in most instances. Figure 4 is preferred, however, only for the reason that it gives more conservative results and use of the values shown will normally lead to hydrate free operation in the field.

The presence of liquid water in the lines accelerates the formation of hydrates in sufficient quantity to form a plug. This has led most operators to feel that the elimination of this liquid is the first step in minimizing freezing. When this water is present the hydrates may form rapidly in large quantities. These hydrates then serve as a collection point for future buildup. This contention about liquid water is continually proven in transmission systems when line plugging is eliminated by the use of an efficient free water knockout. Such a knockout alone will not replace a dehydrator but often eliminates serious plugging when the system is operating at or near the hydrate point.

It is not the intention to infer that hydrates will form only in the presence of substantial quantities of liquid water, for such is not the case. The water simply serves to consolidate these hydrates at a temperature where the unconsolidated solid *might* not cause serious trouble. These hydrates can travel long distances but usually hang up eventually in a regulator or meter run. Even if no complete plugging occurs it decreases the gas flow and interferes with metering. The ice often gradually builds up on a regulator and eventual plugging of the valve occurs at regular intervals.

These pressure regulators provide a source of trouble because of the temperatures drop accompanying expansion. Many operators combat this by installing a choke either in or adjacent

to a line heater. This method may be very satisfactory providing that the heat requirement to prevent hydrates is not too great, for the heat transfer through a valve body is limited. Where large pressure drops must be taken it is best to take it in increments with a heat supply for each. When a diaphragm motor valve is used it is customary to use a steam tracer or a jacketed valve.

Even with heating it is important to keep the gas velocity high and provide a valve with a constant cross-section and straight through flow. With many valves hydrates can build up under the seat ring and eventually plug the valve.

Once hydrates form they may be removed by external heating, lowering the line pressure or by the injection of inhibitors such as alcohol. In any event the process is time consuming and expensive. Inhibitors, such as alcohol, may be used to prevent hydrates but the use of this method, as compared to dehydration, is open to question in most instances. The exception is the use of glycol injection in conjunction with low temperature separation (see Part V).

Pipe Line Heaters

Even with the improvement of dehydration equipment, line heaters still play an important role particularly in gathering systems. When such heaters are deemed advisable the problem arises as to how far such heat will carry and/or the temperature necessary to carry the gas a given distance. Reid[110] has developed an equation to predict these values. His proposed equation is

$$\ln(t_2-t_e) = \ln(t_1-t_e) - \frac{\pi\, DUL}{12\, wCp}$$

where t_1 = temperature of gas leaving the heater — °F.
t_2 = temperature of gas after traveling distance L — °F.
t_e = ground temperature — °F.
π = 3.1416
D = average pipe diameter — inches
L = length gas travels — ft.
w = weight flow of gas —lb. per hr.
Cp = specific heat of gas, Btu/lb. — °F.
U = over-all heat transfer coefficient, Btu/hr. — sq. ft. — °F.

The specific heat of various gravity gases may be obtained from data correlated by Laurence and Reid.[84] No general correlation for the prediction of *U* is available although scattered data show it to have a value of about 2.0. Reid obtained data on 4 to 14-inch pipe, buried 30 inches deep, at gas pressures ranging from 900-1100 psig. His values varied from 1.85 to 2.35. All data point to the fact that the heat transfer is some function of the soil composition. However, these values are indicative of the range of values to be expected.

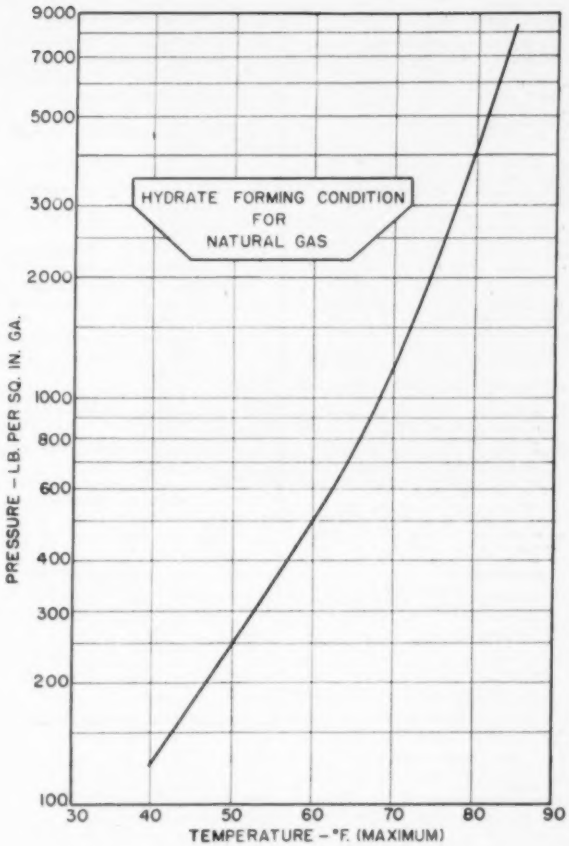

Figure 4. Prediction Of Hydrate Formation Temperature at a Given Pressure.

Summary

All methods of dehydration, regardless of the exact mechanism, are merely a means of increasing the forces which cause water to condense while decreasing the tendency to revaporize. It is not the absolute but the relative value of these forces that is of the utmost importance to cause the condensing forces to be predominate, i.e., reduce the value of y in Equations (1) and (2). In each of the four methods the means of accomplishing this has been discussed.

End of Part I. Part II will appear in an early issue.

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NOMENCLATURE

A — arbitrary constant

c — concentration of water in the gas

Cp — specific heat of gas — Btu/lb. — °F. —

D — average pipe diameter — inches

k — arbitrary constant.

K — vapor-liquid equilibrium constant.

L — length — feet.

n — arbitrary constant.

P — absolute pressure — psia.

s — wt. of water adsorbed per unit wt. of desiccant, at saturation.

t_g — ground temperature — °F.

t_H — hydrate formation temperature — °F.

t_2 — temperature of gas after cooling in distance L — °F.

t_1 — temperature of gas leaving heater — °F.

U — over-all heat transfer coefficient — Btu/hr. — sq. ft. — °F.

w — wt. flow rate of gas — lb./hr.

x′ — wt. of water adsorbed per unit wt. of desiccant.

x — mol fraction water in liquid phase.

y — mol fraction of water in the gas (equiv. to volume fraction).

π — 3.1416.

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Wide Range of Feed Stocks Possible with Airlift TCC

Yields of motor gasoline on once-through operations range from 37.1 percent for Slaughter gas oil to 46 percent for Mirando gas oil at same carbon factor

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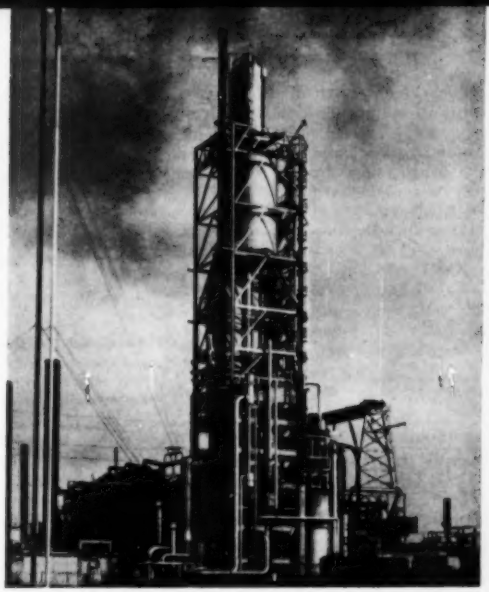

Fifteen thousand-barrel-daily TCC Airlift installation at Trenton, Mich.

THE FIRST Airlift TCC unit was put on stream in October, 1950, at the Beaumont, Texas, refinery of Magnolia Petroleum Company. By early 1952 13 additional units had been placed on stream and construction has been started or authorized for 21 additional units. The total cracking capacity of these 35 Airlift TCC units, now in operation or approved to date, amounts to more than 400,000 barrels daily. This new-type TCC unit was developed and is licensed solely by Socony-Vacuum Oil Company, Inc.

The new Airlift TCC unit offers many improvements over the bucket-elevator type TCC unit while retaining all the important advantages associated with the older unit; e.g., high liquid recovery, high cracking efficiency, high equilibrium catalyst activity and high ratios of gasoline to gas and to coke. A simplified diagram of the new unit is shown in Figure 1.

The new unit differs from its predecessor in three major respects.

- The Airlift TCC unit employs a pneumatic lift to elevate the catalyst to the top of the unit. The commercial Airlift TCC units in operation are showing low catalyst attrition rates in line with those predicted from the experimental lift. The operating units are showing bead catalyst make-up requirements ranging from 0.2 to 0.4 pounds per barrel of charge.
- The reactor has been superimposed above the kiln; therefore, the catalyst is elevated only once for each complete cycle through the unit. With this design there is only one catalyst level in the system which must be controlled. These features contribute greatly to operating simplicity.
- The catalyst circulation rate has been increased to permit a major simplification of the kiln by elimination of multiple-stage regeneration with all of its attendant internal equipment. The new kiln employs split-flow of the regeneration air and has only one set of cooling coils.

The higher catalyst-to-oil ratio also permits operation at higher conversion levels. At the same time, it should be noted that the catalyst-to-oil ratio is kept as low as possible consistent with the foregoing requirements, since further increases in catalyst circulation cause the undesirable results of more catalyst attrition, higher utility and investment requirements, higher coke production and lower liquid recovery without providing compensating advantages.

Reactor and Kiln Capacities

Airlift TCC units have been fully engineered which have reactor charge capacities ranging from 1500 to 25,000 barrels daily. Kiln carbon-burning capacities range from 1100 to 12,500 pounds per hour. A unit of essentially any other capacity can be designed for a specific installation if one of the units already engineered is not of proper size. Units in the smaller sizes, namely 1500 to 6000-barrel-daily capacity, are available as "package" or prefabricated units. The "package-type" TCC unit makes catalytic cracking available to the small refinery with an investment cost per barrel in line with that for the larger units.

Operating Variables

Although each TCC unit is generally designed to charge a specific feed stock and to produce specific products, any given unit has considerable flexi-

TABLE 1—Properties of TCC Charge Stocks

STOCK	Mid-Continent Wide Cut Gas Oil	Mid-Continent Heavy Gas Oil	Mirando Wide Cut Gas Oil	Scurry County Wide Cut Gas Oil	Slaughter W. Texas Gas Oil	Tibu-Petrolea (Columbia) Wide Cut Gas Oil	Iranian Mixture Wide Cut Gas Oil
Cut on Crude, Percent Vol.	44.5-89.5	59.7-89.5	4.5-94.8	62.4-92.8	34.0-83.0	37.0-80.0	30.8-80.9
Properties:							
Gravity, °API	29.6	26.8	21.4	28.5	26.2	30.7	30.5
Bromine Number	7.0	7.4	7.5	12.0	12.3	5.6	10.4
Aniline Point, °F.	178	187	132	183	186	191	168
Pour Point, °F.	85	90	<-30	90	80	85	75
Sulfur, Percent Wt.	0.41	0.58	0.17	0.37	2.34	0.75	1.28
Conradson Carbon, Percent Wt.	0.13	0.23	0.12	0.20	0.28	0.29	0.08
Viscosity, KV @ 100° F.	15.9	38.1	14.8	19.5	13.8	15.1	.....
Viscosity, KV @ 210° F.	3.35	5.52	.....	3.71	3.08	3.30	.....
Distillation, Vacuum Assay, °F.:							
IBP	478	600	400	450	525	444	450
10 percent Vol.	568	640	482	580	572	555	508
50 Percent Vol.	712	780	603	750	698	734	661
90 Percent Vol.	912	980	853	920	948	931	896
95 percent Vol.	950	1010	890	960	980	962	932

bility with respect to both. This flexibility is obtained by changes in one or more of the operating variables. The major TCC process variables and the usual range through which each can be varied is as follows:

1) Space velocity—1.0 to 3.0 volumes of oil per hour per volume of catalyst in the reactor (volume per hour per volume).
2) Catalyst to oil ratio—2.0 to 6.0 volumes of catalyst per hour per volume of oil per hour (volume per volume).
3) Reactor average temperature—850 to 925° F.
4) Catalyst activity—25 to 32 CAT-A index.
5) Recycle to fresh feed ratio—0 to 1.5 volumes of recycle per hour per volume of fresh feed.

Certain combinations of the above variables can be selected to give large changes in product yields from a given stock, or to accommodate variations in charge stocks. Naturally, it is not commercially practical to design all combinations of all process variables in a given unit. The variables most commonly adjusted in commercial operations are average reactor temperature, a function of oil and catalyst inlet temperatures and cata-

TABLE 2—Typical TCC Yields from Various Charge Stocks
(Type of Operation: once-through. Catalyst: 31 Al Beads)

CHARGE STOCK	Mid-Continent Wide-Cut Gas Oil	Mid-Continent Heavy Gas Oil	Mirando Wide Cut Wide-Cut Gas Oil	Scurry County Wide-Cut Gas Oil	Slaughter W. Texas Gas Oil	Tibu-Petrolea Wide-Cut Gas Oil	Iranian Mixture Wide-Cut Gas Oil
Cut on Crude, Percent Vol.	44.5-89.5	59.7-89.5	4.5-94.8	62.1-92.5	34.0-83.0	37.0-80.0	30.8-80.9
Oil Inlet Temp., °F.	810	810	810	810	810	810	810
Catalyst Inlet Temp., °F.	1035	1050	1035	1040	1035	1035	1050
Average Reactor Temp., °F.	885	885	880	870	880	885	880
Space Velocity, Total Feed, V Hr/V	1.3	2.0	1.5	1.5	1.6	1.4	1.15
Catalyst to Total Feed Ratio, Vol.	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Steam, Percent Wt. Total Feed	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Pressure, psig.	10	10	10	10	10	10	10
Conversion, Percent Vol.	55.5	51.6	55.5	55.9	49.9	59.1	52.3
Yields on Fresh Feed:							
Heavy Fuel Oil, Percent Vol.	18.1	30.9	6.6	18.7	18.3	17.0	9.7
Light Fuel Oil, Percent Vol.	26.4	17.5	37.9	25.4	31.8	23.9	38.0
C_4 Free Motor Gasoline, 385 @ 90 Percent Vol.	40.5	38.8	43.0	40.8	35.2	41.9	37.2
Total C_4's, Percent Vol.	14.3	12.5	13.5	14.4	13.6	16.7	13.2
Dry Gas, Percent Wt.	6.8	6.0	6.3	6.3	6.9	7.3	6.7
Coke, Percent Wt.	3.9	3.8	3.7	3.9	3.8	3.9	3.9
C_4 Free Liquid Recovery, Percent Vol.	99.3	99.7	101.0	99.3	98.9	99.5	98.1
Light Hydrocarbons							
NC_4, Percent Vol.	2.1	1.8	2.6	2.2	1.8	2.2	2.0
IC_4, Percent Vol.	7.5	6.4	8.9	8.0	6.8	9.5	6.7
$C_4=$, Percent Vol.	4.7	4.3	2.0	4.2	5.0	5.0	4.5
Total, Percent Vol.	14.3	12.5	13.5	14.4	13.6	16.7	13.2
C_3, Percent Wt.	1.9	1.7	2.1	2.0	1.6	2.1	1.8
$C_3=$, Percent Wt.	2.6	2.4	2.2	2.4	2.7	3.1	2.3
C_3 + Lighter, Percent Wt.	2.3	1.9	2.0	1.9	2.6	2.1	2.6
Total Percent Wt.	6.8	6.0	6.3	6.3	6.9	7.3	6.7
10 RVP TCC Motor Gasoline:							
Yield, Percent Vol.	42.4	41.0	46.0	42.7	37.1	43.7	39.8
Excess C_4's, Percent Vol.	12.4	10.3	10.5	12.5	11.7	14.9	10.6
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	92.2 79.5	93.0 79.3	96.2 83.5	92.4 81.0	92.3 80.2	92.1 80.1	90.5 79.8
3 cc TEL	98.0 85.5	98.7 85.5	(no +0.05) 89.0	98.7 87.0	97.5 85.0	98.2 85.7	96.5 85.0
10 RVP TCC + C_3 Alkylate Motor Gasoline:							
Yield, Percent Vol.	51.3	48.2	49.7	50.6	45.5	53.3	47.4
Excess C_4's, Percent Vol.	0.6	0.8	5.5	2.0	0.6	2.2	0.6
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	92.4 81.5	93.1 81.2	96.0 84.1	92.6 82.7	92.7 82.3	92.4 82.2	91.0 81.7
3 cc TEL	98.9 88.3	99.4 88.0	(no +0.07) 90.0	99.4 89.3	98.6 88.1	99.1 89.0	97.6 87.7
10 RVP TCC + Catalytic $C_3=$ + $C_4=$ Polymer Motor Gasoline:							
Yield, Percent Vol.	47.8	45.9	49.9	47.5	42.7	49.7	44.8
Excess C_4's, Percent Vol.	7.9	6.2	8.0	8.3	7.0	10.1	8.3
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	93.6 80.7	94.2 80.7	97.3 84.3	93.6 81.9	94.0 81.5	93.6 81.3	92.2 80.9
3 cc TEL	98.4 85.8	98.9 85.8	(no +0.11) 89.3	98.9 87.1	98.0 85.5	98.6 86.0	97.1 85.4

TABLE 3
Properties of Products from TCC Cracking Various Charge Stocks

CHARGE STOCK	MID-CONTINENT WIDE-CUT GAS OIL			MID-CONTINENT HEAVY GAS OIL			MIRANDO WIDE-CUT GAS OIL			SCURRY COUNTY WIDE-CUT GAS OIL			SLAUGHTER W. TEX. GAS OIL			TIBU-PETROLEA WIDE-CUT GAS OIL			IRANIAN MIXTURE WIDE-CUT GAS OIL		
PRODUCT	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil	10 RVP Motor Gasoline	Light Fuel Oil	Heavy Fuel Oil
Properties:																					
Gravity, °API	57.4	28.4	23.5	58.3	23.8	23.9	59.9	20.5	13.4	58.1	25.8	22.0	57.9	25.3	19.8	59.3	28.8	23.9	58.8	31.3	15.3
Bromine Number	63.2	11.2	—	73.0	16.8	—	26.0	10.8	—	37.0	13.5	—	48.5	—	—	54.4	9.6	—	57.0	—	—
Aniline Point	—	147	178	—	120	182	—	99	—	—	127	173	—	127	—	—	142	183	—	144	175
Pour Point, °F.	—	10	75	—	10	75	—	<-25	50	—	15	80	—	10	80	—	10	75	—	10	80
Sulfur, % Wt.	0.02	.42	0.59	0.06	.61	0.88	0.04	.14	0.30	0.04	.38	0.52	0.26	2.0	2.78	0.08	.84	0.92	0.13	1.20	2.02
Conradson Carbon Residue, % Wt.		<0.01	1.0		0.01	0.08	—	<0.01	0.0	—	0.01	1.10	—	0.02	1.3	—	<0.01	1.2	—	0.03	1.3
Viscosity, KV @ 100 °F.		4.02	16.2		4.11	21.5	—	3.75	500	—	3.90	18.5	—	3.78	—	—	3.79	17.53	—	3.31	21.5
Viscosity, KV @ 210 °F.		—	3.35		—	3.98	—	—	12.8	—	—	3.50	—	—	3.60	—	—	3.45	—	—	3.52
Distillation, °F.:																					
IBP	93	492	608	93	488	600	87	475	597	89	495	610	95	455	600	93	500	637	85	435	600
10% Vol.	115	517	663	116	512	672	115	492	710	115	515	685	114	482	695	115	515	682	110	481	698
50% Vol.	220	552	712	227	555	745	272	518	754	225	548	720	230	532	755	214	541	718	227	529	753
90% Vol.	385	597	813	385	600	865	385	592	890	385	597	810	385	600	863	382	592	834	385	598	861
E.P.	425	620	—	418	625	—	415	632	—	422	618	—	432	627	—	436	615	—	427	632	—
Cetane No.	—	51.5	—	—	34.5	—	—	25	—	—	39.8	—	—	—	—	—	—	—	—	—	—
Diesel Index	—	41.7	—	—	28.7	—	—	20.2	—	—	32.8	—	—	32.1	—	—	41.0	—	—	45.0	—

lyst-to-oil ratio; space velocity, a function of bed depth; and catalyst-to-oil ratio, a function of catalyst circulation rate.

Both bead synthetic and clay natural catalysts are used in Airlift TCC units. Discussed are operations on bead catalyst which is more generally used.

Airlift TCC units are being designed to process gas oils from a large variety of crudes. Although the charge stock from a given crude may vary in boiling range from a very light to very heavy gas oil, the most common cut available for catalytic cracking is the gas oil fraction between kerosine or light fuel oil and asphalt. Properties of typical TCC charge stocks from six of the more common crudes are shown in Table 1. These include wide-cut gas oils (above kerosine) from Mid-Continent, Mirando, Scurry County, Slaughter, Colombia, and Iranian mixed crudes. Properties for a heavier gas oil (above light fuel oil) from Mid-Continent crude are also included.

The charge stock for TCC units may be prepared by any conventional method, such as, distillation, solvent deasphalting, or coking. A method commonly used for TCC installations (and which is most economical in many cases) is to preheat the reduced crude from the straight run unit to about 825° F. and flash it in a tar separator (see Figure 1). The tar separator overhead goes directly to the TCC reactor as vapor feed. The tar separator bottoms are flashed without additional heat in a vacuum flash unit, and the overhead vapor is condensed, reheated and injected into the TCC reactor as liquid feed. An alternate method, of course, is to charge the entire reduced crude to a vacuum unit, but this method requires condensation and reheating of the entire TCC feed as compared with condensing and reheating only a part of the feed in the first scheme. Other types of feed preparation systems can employ visbreaking or coking. The TCC unit also provides flexibility by permitting the charging of whole crude to the tar separator whereby the straight-run gasoline is processed through the TCC reactor along with the gas oil.

TCC Yields

Typical yields which can be obtained by once-through cracking of the charge stocks described above are shown in Table 2. All of the yields are for concurrent flow over equilibrium 31 activity index bead catalyst at 4.7 catalyst-to-oil ratio, about 880° F. average reactor temperature and at a constant carbon yield. The only process variable which was adjusted to compensate for the different coke-forming characteristics of the various stocks was space velocity.

The once-through yield of 10-RVP motor gasoline for this type of operation ranges from 46.0 percent volume for Mirando gas oil to 37.1 percent volume for Slaughter gas oil. Processing the gas oil above light fuel oil, as compared with the gas oil above kerosine, from Mid-Continent crude produces about 1.4 percent volume lower yield of 10-RVP motor gasoline at the same carbon yield. The yield of gaso-

TABLE 4

Effects of Increasing Coke Production on Product Yields

(Type of Operation: once-through. Catalyst: 31 AI Beads)

CHARGE STOCK	Mid-Continent Heavy Gas Oil		
Cut on Crude	59.7-89.5		
Operating Conditions:			
Oil Inlet Temp. °F.	810	810	810
Catalyst Inlet Temp., °F.	1050	1015	990
Average Reactor Temp., °F.	885	885	885
Space Velocity, Total Feed, V/Hr/V	2.0	1.4	1.0
Catalyst to Total Feed Ratio, Vol.	4.7	6.2	7.9
Steam, Percent Wt. Total Feed	5.0	5.0	5.0
Pressure, psig	10	10	10
Conversion, Percent Vol.	51.6	59.4	66.5
Yields on Fresh Feed:			
Heavy Fuel Oil, Percent Vol.	30.9	24.4	18.0
Light Fuel Oil, Percent Vol.	17.5	16.1	15.5
C_5 Free Motor Gasoline, 385 @ 90 Percent, Percent Vol.	38.8	44.0	47.9
Total C_4's, Percent Vol.	12.5	14.5	16.5
Dry Gas, Percent Wt.	6.0	6.7	7.7
Coke, Percent Wt.	3.8	5.1	6.4
C_3 Free Liquid Recovery, Percent Vol.	99.7	99.0	97.9
Light Hydrocarbons:			
NC_4, Percent Vol.	1.8	2.2	2.6
IC_4, Percent Vol.	6.4	7.7	9.0
C_4=, Percent Vol.	4.3	4.6	4.9
Total, Percent Vol.	12.5	14.5	16.5
C_3, Percent Wt.	1.7	2.0	2.3
C_3=, Percent Wt.	2.4	2.5	2.7
C_2 + Lighter, Percent Wt.	1.9	2.2	2.7
Total, Percent Vol.	6.0	6.7	7.7
10 RVP TCC Motor Gasoline:			
Yield, Percent Vol.	41.0	46.4	50.8
Excess C_4's, Percent Vol.	10.3	12.1	13.6
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	93.0 79.5	92.8 79.4	93.1 79.6
3 cc TEL	98.7 85.5	98.5 85.4	98.9 85.6
10 RVP TCC + C_4 Alkylate Motor Gasoline:			
Yield, Percent Vol.	48.2	55.1	60.3
Excess C_4's, Percent Vol.	0.8	0.7	1.2
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	93.1 81.2	92.9 81.3	93.2 81.5
3 cc TEL	99.4 88.0	99.2 88.1	99.6 88.2
10 RVP TCC + Catalytic C_3= + C_4= Polymer Motor Gasoline:			
Yields, Percent Vol.	45.9	51.7	56.4
Excess C_4's, Percent Vol.	6.2	7.6	8.9
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	94.2 80.7	93.9 80.5	94.3 81.0
3 cc TEL	98.9 85.8	98.8 85.7	99.1 86.0

PART 5

Effect of Temperature Severity on Product Yields

(Type of Operation: once-through. Catalyst: 31 AI Beads)

CHARGE STOCK	Mid-Continent Wide-Cut Gas Oil		
Cut on Crude, Percent Vol.	44.5-89.5		
Operating Conditions:			
Average Reactor Temp., °F.	860	885	925
Oil Inlet Temp., °F.	810	810	810
Catalyst Inlet Temp., °F.	985	1035	1115
Space Velocity, Total Feed, V/Hr/V	1.15	1.3	1.6
Catalyst to Total Feed Ratio, Vol.	4.7	4.7	4.7
Steam, Percent Wt. Total Feed	5.0	5.0	5.0
Pressure, psig	10	10	10
Conversion, Percent Vol.	55.1	55.5	56.0
Yields on Fresh Feed:			
Heavy Fuel Oil, Percent Vol.	18.5	18.1	18.9
Light Fuel Oil, Percent Vol.	26.4	26.4	25.1
C_5 Free Motor Gasoline, 385 @ 90 Percent, Percent Vol.	41.3	40.5	39.1
Total C_4's, Percent Vol.	13.8	14.3	14.4
Dry Gas, Percent Wt.	6.0	6.8	8.2
Coke, Percent Wt.	3.9	3.9	3.9
C_3 Free Liquid Recovery, Percent Vol.	100.0	99.3	97.5
Light Hydrocarbons:			
NC_4, Percent Vol.	2.0	2.1	1.9
IC_4, Percent Vol.	7.8	7.5	7.1
C_4=, Percent Vol.	4.1	4.7	5.4
Total, Percent Vol.	13.8	14.3	14.4
C_3, Percent Wt.	1.8	1.9	2.1
C_3=, Percent Wt.	2.3	2.6	3.1
C_2 + Lighter Percent Wt.	1.9	2.3	3.0
Total, Percent Wt.	6.0	6.8	8.2
10 RVP TCC Motor Gasoline:			
Yield, Percent Vol.	43.2	42.4	41.0
Excess C_4's Percent Vol.	11.9	12.4	12.5
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	90.5 79.0	92.2 79.5	94.0 80.3
3 cc TEL	97.3 85.5	98.0 85.5	99.0 85.5
10 RVP TCC + C_4 Alkylate Motor Gasoline:			
Yield, Percent Vol.	51.0	51.3	47.9
Excess C_4's, Percent Vol.	1.7	0.6	0
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	91.0 80.9	92.4 81.5	93.9 82.3
3 cc TEL	98.3 88.0	98.9 88.3	99.8 88.5
10 RVP TCC + Catalytic C_3= + C_4= Polymer Motor Gasoline:			
Yield, Percent Vol.	47.9	47.8	47.2
Excess C_4's, Percent Vol.	8.0	7.9	7.4
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	92.0 80.1	93.6 80.7	95.2 81.5
3 cc TEL	97.7 85.8	98.4 85.8	99.3 85.9

line from all stocks except Mirando can be increased by about 8 percent volume by alkylation of the available butylenes[1] or about 5 percent volume by catalytic polymerization of the butylenes and propylene[2] from the TCC operation. The Mirando gas oil produces a lower yield of unsaturated light hydrocarbons, which results in a lower yield of alkylate (3.7 percent volume)[3] or catalytic polymer (3.9 percent volume).

Product Properties

The properties of the TCC products vary to some extent with the properties of the TCC charge and the severity of the cracking operation. A summary of the properties of the cracked products from TCC processing the gas oils described above is shown in Table 3.

TCC gasoline is well known to have excellent quality so that treating of the gasoline is no particular problem. Normal refinery gasoline treating procedures; i.e., caustic treating and water washing, followed by a short interval of storage, will produce a doctor-sweet gasoline from all the charge stocks listed, including the high-sulfur Slaughter gas oil. If inhibitor is used the quantity added is in the range of only 2 to 3 pounds per 1000 barrels. Sulfur contents of the TCC gasoline are usually about 6 to 8 percent of the sulfur content of the charge stock. The octane ratings of the 10 RVP TCC gasolines range from 90.5 to 96.2 F-1 unleaded and from 96.5 to iso + .05 cc TEL F-1 with 3 cc TEL. The addition of alkylate or catalytic polymer to the TCC gasoline increases the leaded F-1 octane number by 0.8 and 0.4, respectively.

The TCC distillate fuel oil, above a 385° F. at 90 percent motor gasoline and having a 595° F. at 90 percent goes into No. 2 fuel oil, and it is known that relatively high percentages of TCC distillate fuel oil can be blended into saleable No. 2 fuel oil. Addition of minor percentages of kerosine is sometimes necessary to meet volatility specifications for No. 2 fuel oil. This TCC distillate fuel oil has a pour point of about —25° F. for naphthenic stocks and a pour point in the range of 10 to 15° F. for paraffinic stocks. Cetane numbers for these base stocks vary from about 50 for the Mid-Continent wide-cut gas oil to 25 for the Mirando gas oil. TCC processing stocks free of No. 2 fuel oil produce distillate fuel oils with cetane numbers lower than those obtained from wide-cut gas oils. For example, the No. 2 fuel oil from a Mid-Continent heavy gas oil has a cetane number 17 points lower than the fuel oil from a wide-cut gas oil. The sulfur content of the TCC light fuel oil is generally about 85 percent of the sulfur content of the charge stock.

The heavy catalytic fuel oil produced from TCC cracking provides a satisfactory cutter stock for blending with heavy tars to produce residual fuel oils. The sulfur content of the heavy fuels is about 150 percent of the sulfur content of the charge stock.

TABLE 6
Effect of Recycle Cracking on Product Yields
(Catalyst: 31 Al Beads)

CHARGE STOCK	Mid-Continent Wide-Cut Gas Oil				
Cut on Crude, Percent Vol. oo	44.5-89.5				
Operating Conditions:					
Recycle to Fresh Feed Ratio, Vol.	0	0.3	0.5	1.0	1.5
Oil Inlet Temp., °F.	810	810	810	810	810
Catalyst Inlet Temp., °F.	1035	1035	1035	1035	1035
Average Reactor Temp., °F.	885	885	890	895	900
Space Velocity, Total Feed, V./Hr./V.	1.3	1.7	1.6	1.8	1.9
Catalyst to Total Feed Ratio, Vol.	4.7	4.7	4.7	4.7	4.7
Steam, Percent Wt. Total Feed	5.0	5.0	5.0	5.0	5.0
Pressure, psig	10	10	10	10	10
Recycle:					
Gravity, °API		22.5	25.0	22.5	20.0
Boiling Range, °F.		600-900	600-900	600-900	600-900
Conversion, Percent Vol.	55.5	65.2	73.6	84.8	93.0
Yields on Fresh Feed:					
Heavy Fuel Oil, Percent Vol.	18.1	7.0	11.0	8.0	5.9
Light Fuel Oil, Percent Vol.	26.4	27.8	15.4	7.2	1.1
C_5 Free Motor Gasoline, 385 @ 90 Percent, Percent Vol.	40.5	46.6	51.6	57.6	61.6
Total C_4's, Percent Vol.	14.3	17.1	19.4	22.4	24.4
Dry Gas, Percent Wt.	6.8	8.3	9.8	11.8	13.7
Coke, Percent Wt.	3.9	5.1	5.9	7.8	9.7
C_5 Free Liquid Recovery, Percent Vol.	99.3	98.5	97.4	95.4	93.0
Light Hydrocarbons:					
$N-C_4$'s, Percent Vol.	2.1	2.6	3.0	3.5	3.8
IC_4, Percent Vol.	7.5	8.8	9.9	11.4	12.4
$C_4=$, Percent Vol.	4.7	5.7	6.5	7.5	8.2
Total, Percent Vol.	14.3	17.1	19.4	22.4	24.4
C_3, Percent Wt.	1.9	2.1	2.5	2.9	3.2
$C_3=$ Percent Wt.	2.6	3.3	3.8	4.5	5.2
C_2 + Lighter, Percent Wt.	2.3	2.9	3.5	4.4	5.3
Total, Percent Wt.	6.8	8.3	9.8	11.8	13.7
10RVP TCC Motor Gasoline:					
Yield, Percent Vol.	42.4	48.7	53.7	59.8	63.6
Excess C_4's, Percent Vol.	12.4	15.0	17.3	20.4	22.4
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	92.2 79.5	92.2 79.5	92.5 79.7	92.7 79.9	93.0 80.0
3 cc TEL	98.0 85.5	98.0 85.5	98.2 85.6	98.4 85.7	98.5 85.8
10 RVP TCC + C_4 Alkylate Motor Gasoline:					
Yield, Percent Vol.	51.3	59.5	66.0	74.0	79.1
Excess C_4's, Percent Vol.	0.6	0.8	1.0	1.7	1.9
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	92.4 81.5	92.4 81.7	92.7 81.9	92.9 82.1	93.1 82.3
3 cc TEL	98.9 88.3	98.9 88.5	99.1 88.7	99.3 88.8	99.4 89.0
10 RVP TCC + Catalytic $C_3=$ + $C_4=$ Polymer Motor Gasoline:					
Yield, Percent Vol.	47.8	55.2	61.3	68.6	73.5
Excess C_4's, Percent Vol.	7.9	9.6	11.1	13.3	14.6
Octane Numbers	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2	F-1 F-2
0 cc TEL	93.6 80.7	93.6 80.8	93.9 81.0	94.2 81.2	94.5 81.3
3 cc TEL	98.4 85.8	98.4 85.9	98.6 86.0	98.8 86.1	98.9 86.2

Effect of Carbon-Burning Capacity on Yields

The effect of increasing carbon-burning capacity in TCC operations on product yields is shown in Table 4. As previously mentioned the gasoline-to-coke ratio is very attractive in TCC operations. Thus it will be noted from the yields in the tables that the coke make is remarkably low for the gasoline yield at any given level. Table 4 shows the product yields from the Mid-Continent heavy gas oil at a carbon factor of 0.5, 0.67, and 0.83 pounds per hour carbon per barrel per day feed. The change in conversion level and cracking severity for these operations is obtained by simultaneously decreasing space velocity and increasing catalyst-to-oil ratio at the same average reactor temperature. The net result, comparing the yields at 0.5 and 0.83 carbon factor, is an increase in conversion level from 51.6 percent to 66.5 percent which results in an increase in 10-RVP motor gasoline (from 41.0 to 50.8 percent volume), excess butanes and dry gas, primarily at the expense of heavy fuel oil yield. The octane number of the motor gasoline remains about the same. The yield of alkylate increases from 7.2 to 9.5 percent volume and the yield of catalytic polymer increases from 4.9 to 5.6 percent volume.

Effect of Cracking Temperature

The effect of varying average reactor temperature on product yields at a constant coke production is shown in Table 5. These yields are based on cracking the Mid-Continent wide-cut gas oil at 860, 885, and 925° F. at a 0.5 carbon factor. As temperature is increased, space velocity is also in-

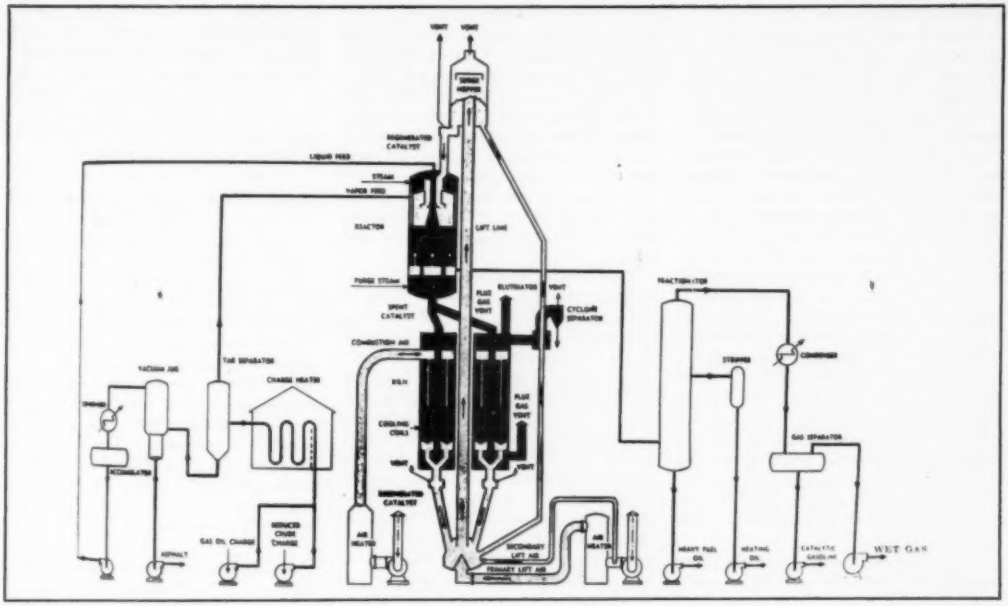

Figure 1. Airlift TCC Catalytic Cracking Process.

creased to maintain the same coke yield. The net result of increasing the temperature from 860 to 925° F. in this manner is a loss in 10-RVP TCC motor gasoline (43.2 to 41.0 percent volume), light fuel oil, and liquid recovery; and an increase in dry gas, total butanes, and unsaturates. In the TCC process an increase in temperature, with all other factors remaining constant, increases the octane number of the catalytic gasoline. Thus the leaded research octane number of the TCC gasoline increases 1.7 points for the temperature change noted above. The yield of total 10-RVP gasoline, including either alkylate or catalytic polymer, is essentially constant over the temperature range since the incremental gain in butylene and propylene due to the higher temperature is sufficient when converted to alkylate or polymer to just about offset the loss in TCC gasoline.

Effect of Recycle Cracking on Product Yields

In cases where charge stock availability is limited, recycling of catalytic gas oil is frequently practiced to meet gasoline production. Recycle operations are advantageous in TCC operations because the TCC recycle stocks are relatively less refractory than many recycle stocks. Hence, high gasoline yields are obtained from TCC recycle processing. In general, the preferred recycle stock is catalytic heavy fuel oil since it is the lowest value liquid product. If the quantity of heavy fuel oil is insufficient to fill a unit to capacity, or to meet a specific product distribution, then the catalytic light fuel oil is included in the recycle stream. The effect of recycling heavy and wide-cut catalytic fuel oils on the products from processing the Mid-Continent wide-cut gas oil is presented in Table 6. The operating variables were held constant in all cases with the exception of space velocity, which is adjusted as recycle to fresh feed ratio is changed to keep the coke production (weight percent of total feed) constant.

Recycling a 600 to 800° F. catalytic heavy fuel oil to the extent of 0.3 recycle to 1 fresh feed results in an increase in conversion level from 55.5 percent to 65.2 percent and increases the yield of 10-RVP TCC gasoline from 42.4 to 48.7 percent volume. The octane quality of the gasoline remains about the same. The change in yields when recycling a 400 to 800° F. fraction is similar to that for recycling a heavy gas oil, except that the gain in yields is at the expense of both heavy and light fuel oils. The operation at a recycle to fresh feed ratio of 1.5 shows a 10-RVP TCC gasoline yield of 63.6 percent volume at a conversion level of 93 percent. This yield of gasoline can be increased to 73.5 percent volume if catalytic polymer is included or to 79.1 percent volume if alkylate is included. As the amount of recycling is increased, a slight rise in average reactor temperature occurs at the same oil and catalyst inlet temperatures. This increase in average reactor temperature results in a small increase in octane quality of the gasoline.

Selection of Optimum Process Conditions

The effects of the individual process variables have been discussed in the preceding paragraphs primarily with respect to gasoline yield. The selection of a set of process conditions for a specific installation requires study of a number of cases selected to fit in with the existing processing facilities and the desired product distribution and quality. The cost of each operation (feed preparation, cracking, fuel blending, and light ends recovery) and the product revenue from each case must be evaluated in order to select the optimum processing scheme.

Yields from Commercial Airlift Units

All the data presented up to this point are representative of commercial operation but are based on pilot plant information, which, as noted later, checks commercial operations closely. Typical yields from five Airlift units, each designed for a charge rate of 15,000 barrels daily and a carbon burnoff of 7500 pounds per hour are

shown in Table 7. (See below.)

Units 1 and 2 were processing vaporized gas oils; No. 1 a Jackson gas oil and No. 2 a mixture of Mid-Continent and West Texas virgin and visbroken gas oils. The remaining three units were charging a mixed vapor-liquid feed. No. 3 a Mid-Continent gas oil containing 10 percent volume of liquid feed, No. 4 a Kansas gas oil containing 6 percent volume of liquid feed, and No. 5 an Illinois gas oil containing 11 percent volume of liquid feed. Units 3 and 5 are recycling heavy catalytic gas oil, No. 3 at 0.28 to 1 and unit No. 5 at 0.16 to 1 recycle to fresh feed ratio. The other three are essentially once-through operations.

The yield of 10-RVP-385° F. at 90 percent motor gasoline from these operations varies from 42.7 percent volume for Jackson gas oil at low severity (51.3 percent conversion) for No. 1 unit to 52.2 percent volume for Illinois gas oil at moderately high severity (64.9 percent conversion) for No. 5 unit.

The gasoline yields from all these operations could be increased since none of the units are operating at the maximum coke-burning capacity (7500 pounds per hour). Units 1, 2 and 3 were not operated at maximum severity but rather to maximize the yield of No. 2 fuel oil; while Units 4 and 5 did not have adequate charge stock to run at full capacity. However, at various times it has been demonstrated that the units are capable of smooth and easy operation at carbon-burning rates of 7500 pounds per hour and higher.

The octane quality of the motor gasolines is in the range of 94 to 97 F-1 plus 3 cc TEL. Since all these operations are at about the same average reactor temperature (850-870° F.) the differences in octane ratings, for the most part, reflect the gasoline content of the feed. For example, the Jackson gas oil feed to unit No. 1 contained 8 percent volume of gasoline due to inadequate feed-preparation facilities in the refinery. Where direct checks are available, as will be shown later, the quality of the gasoline produced commercially is equivalent to that produced in the pilot unit.

TABLE 7
Yields from Commercial Airlift TCC Units

AIRLIFT TCC UNIT No.	1	2	3	4	5
CHARGE STOCK	Jackson Gas Oil	Mixture Mid-Continent and W. Texas Virgin, and Visbroken Gas Oils	Mid-Continent Wide-Cut Gas Oil	Kansas Wide-Cut Gas Oil	Illinois Wide-Cut Gas Oil
Fresh Feed, B/SD	17790	15740	11486	11420	7800
Gasoline Content, Percent Vol.	8	10	5	2	2
Gravity, °API of Fresh Feed	30.7	31.2	32.5	28.9	28.2
Distillation, ASTM, °F.:					
IBP	296	308	280	300	312
10 Percent Vol.	412	406	460	535	542
50 Percent Vol.	556	606	605	633	692
90 Percent Vol.	716	742	745	727	750
95 Percent Vol.	740	760+	760+	745	760+
Liquid Feed, Percent Vol.			10	6	11
Operating Conditions:					
Bead Catalyst Activity Index	34	32.5	28	32	34
Oil Inlet Temp., °F.	795	800	760, 761[1]	782, 900[1]	786, 686[1]
Catalyst Inlet Temp., °F.	1030	980	1050	947	944
Average Reactor Temp., °F.	870	890	865	840	850
Space Velocity, Total Feed, V/Hr/V	1.90	1.67	1.3	0.98	1.06
Catalyst to Total Feed Ratio, Vol.	3.2	4.0	3.9	5.5	7.1
Steam, Percent Wt. Total Feed	3.1	3.8	2.3	5.8	3.5
Pressure, psig.	10	10	8	7	8
Recycle to Fresh Feed Ratio, Vol.			0.28	0.03	0.16
Total Feed Rate, B/SD	17790	15740	14669	11810	9050
Catalyst Circulation Rate, Tons/Hr	285	310	280	324	320
Carbon Burnoff, Lbs/Hr	4520	6190	5090	7000	6150
Yields on Fresh Feed:					
Heavy Fuel Oil, Percent Vol.	7.5	15.0	9.2	19.1	9.0
Light Fuel Oil, Percent Vol.	41.2	30.5	32.4	19.9	26.1
C_5 Free Motor Gasoline, 385° F. @ 90 Percent, Percent Vol.	39.7	40.9	46.0	42.3	49.5
Total C_4's, Percent Vol.	11.0	13.3	11.1	16.8	13.9
Dry Gas, Percent Wt.	4.9	5.5	5.6	8.9	7.1
Coke, Percent Wt.	2.0	3.1	3.5	4.8	6.1
C_5 Free Liquid Recovery, Percent Vol.	99.4	99.7	98.7	98.1	98.5
Light Hydrocarbons:					
NC_4, Percent Vol.	1.2	1.8	2.0	2.5	2.3
IC_4, Percent Vol.	5.8	6.7	4.5	8.7	7.2
C_4=, Percent Vol.	4.0	4.8	4.6	5.6	4.4
Total, Percent Vol.	11.0	13.3	11.1	16.8	13.9
C_3, Percent Wt.	1.2	1.5	1.4	2.1	1.5
C_3=, Percent Wt.	2.2	2.3	2.0	3.9	2.8
C_2 + Lighter, Percent Wt.	1.5	1.7	2.2	2.9	2.8
Total, Percent Wt.	4.9	5.5	5.6	8.9	7.1
10 RVP Motor Gasoline:					
Yield, Percent Vol. Fresh Feed	42.7	43.5	48.5	44.8	52.2
F-1 + 0 cc TEL			87.5	88.7	88.8
F-1 + 3 cc TEL	95.9	94.2	95.5	96.5	96.5

[1] Liquid feed temperature.

A characteristic of the TCC process which has marked commercial significance is the high liquid recoveries (C_4 and heavier) that are obtained. It will be seen in Table 7 that the commercial liquid recoveries (C_5 and heavier) are very high, ranging from 99.7 for Unit No. 2 to 98.1 for Unit No. 4.

Comparison Yields: Commercial Vs. Pilot Plant

A comparison of the yields and operating conditions for commercial and pilot plant operations has been made in two cases. Accurate yield surveys were taken on units 1 and 3 and samples of catalyst and charge stock from these units were used to make pilot plant runs. A comparison of the results between pilot plant and commercial operations at the same operating conditions is shown in Table 8. It will be noted that the yields of all products show good agreement and that octane ratings of the motor gasolines are also in good agreement.

Aviation Gasoline Blending Stocks

During World War II the TCC process was used to produce large volumes of aviation base stock which was blended into grade 100/130 aviation gasoline. Two types of processing were commonly used: 1) one-pass reforming of a naphthenic or aromatic kerosine, to produce base stock by recycling the charge to extinction, and 2) two-pass processing of light gas oils. In the latter case, gas oil was first cracked to produce a motor gasoline which was then reprocessed with recycling of the heavy naphtha to produce base stock.

The new Airlift TCC units can likewise be used to produce an aviation gasoline base stock by these techniques, with quality equivalent to or better than that produced by the World War II bucket-elevator TCC units. For example, two-pass processing of a paraffinic gas oil gives a 7-RVP base stock yield of 36.0 percent volume based on gas oil, having octane ratings with 4.6 cc TEL of 97.6 F-3 and Isooctane plus 1.64 cc TEL F-4 as shown in Table 9. Up to 74 percent volume of this material can be blended with alkylate to make grade 100/130 aviation gasoline. With an aromatic or naphthenic type charge, both the octane quality and the blend proportions of the base stock will be higher.

It is considerably more difficult to produce a catalytic base stock suitable for blending in grade 115/145 aviation gasoline than for the grade 100/130. In this case two-pass processing of selected charge stocks must be em-

ployed. Thus, the charge to the first pass should be as aromatic or naphthenic as possible; moreover, the first-pass aviation fraction must be removed and only the 325-450° F. fraction charged to the second pass. By applying this technique to a California (naphthenic) gas oil, a 7-RVP base stock yield of 19.6 percent volume having an F-3 rating of 100 and an F-4 blending index of 169 with 4.6 cc TEL was produced, as shown in Table 10. Up to 30.8 percent volume of this product can be blended with alkylate to make grade 115/145 aviation gasoline. The pentane cut produced from the process requires refractionation to prepare a high-purity isopentane for pressuring the grade 115/145 aviation gasoline. In addition to this high quality aviation base stock, 23.3 percent volume of a 300° F. end point gasoline fraction for motor gasoline blending is produced in the first-pass operation.

The preceding part of this paper has described the effects of operating variables and types of charge stock on TCC yields. In order to illustrate the effect of TCC cracking on over-all refinery yields, five TCC processing schemes were developed for a typical refinery processing 30,000 barrels daily of 38.5° API Mid-Continent crude. These five schemes are as follows:

Note—See next page for Table 8.

TABLE 9

Two-Pass TCC Processing for Production of Grade 100/130 Aviation Gasoline Base Stock

(Catalyst: 31 Al Beads)

OPERATIONS	CRACKING	TREATING
Charge Stock	Tiba-Petrolea Gas Oil	First Pass Catalytic Wide-Cut Naphtha
Boiling Range	370-650	Co-450
Operating Conditions:		
Oil Inlet Temp., °F.	820	900
Catalyst Inlet Temp., °F.	1050	1050
Average Reactor Temp., °F.	900	965
Space Velocity, Total Feed, V/Hr/V	1.0	1.0
Catalyst to Total Feed Ratio, Vol.	4.7	4.7
Steam, Percent Wt. Total Feed	0	0
Pressure, psig	10	10
Recycle to Fresh Feed Ratio, Vol.	.....	0.67
Recycle:		
Gravity, °API	.....	37.9
Boiling Range, °F.	.....	335-500
Yields on Fresh Feed:		
Heavy Fuel Oil, Percent Vol.	3.2	4.6
Light Fuel Oil, Percent Vol.	21.7	.....
C_3 Free—450° F. EP Percent Vol.	50.6	.....
C_3 Free 290 °F. @ 90 Percent, Percent Vol.	.....	55.5
Total C_3's, Percent Vol.	6.2	8.6
Total C_4's, Percent Vol.	14.5	15.0
Dry Gas, Percent Wt.	7.9	14.0
Coke, Percent Wt.	3.1	6.2
C_3 Free Liquid Recovery, Percent Vol.	96.2	83.7
Light Hydrocarbons:		
NC_3, Percent Vol.	1.0	0.7
IC_3, Percent Vol.	3.1	5.2
C_3=, Percent Vol.	2.1	2.7
Total, Percent Vol.	6.2	8.6
NC_4, Percent Vol.	2.0	2.4
IC_4, Percent Vol.	7.6	8.8
C_4=, Percent Vol.	4.9	3.8
Total, Percent Vol.	14.5	15.0
C_3, Percent Wt.	2.3	4.3
C_3=, Percent Wt.	3.3	4.2
C_2 + Lighter, Percent Wt.	2.3	5.5
Total, Percent Wt.	7.9	14.0

Stock	Gas Oil Charge	1-Pass Catalytic Treater Charge	7 RVP Base Stock	Grade 100/130 Aviation Gasoline
Yield, Based on Gas Oil Chg., Percent Vol.	100.0	50.6	36.0	48.6[1]
Properties:				
Gravity, °API	34.9	48.8	55.6	60.4
RVP	.....	.....	7.1	7.2
Accelerated Gum, Mgs/100 ml	.....	.....	1.4	.....
Aromatics, Percent Vol.	.....	.....	37.5	.....
Aniline Point, °F.	141	.....	.....	.....
Sulfur, Percent Wt.	0.35	.....	0.016	.....
Distillation, ASTM, °F.:				
IBP	368	152	98	96
10 Percent	435	196	142	143
50 Percent	482	306	205	195
90 Percent	613	406	290	286
EP	653	444	310	315
Octane Ratings:				
F-3 + 4.6 cc TEL	.....	.....	97.6	100.0
F-4 + 4.6 cc TEL	.....	.....	iso+1.64	iso+1.83
F-4 AN Performance No.	.....	.....	134.5	136.5

[1] Represents blend of 74 percent base stock plus 26 percent Alkylate. The octane ratings of the 7-RVP alkylate are 106.3 (F-3) Blending Octane No. and 138.9 (F-4) Index No.

TABLE 10

Two-Pass TCC Processing for Production of Grade 115/145 Aviation Gasoline Base Stock

(Catalyst: 31 Al Beads)

OPERATION	CRACKING	TREATING
Charge Stock	Kettleman Gas Oil	First Pass Catalytic Heavy Naphtha
Boiling Range	380-650	325-450
Operating Conditions:		
Oil Inlet Temp., °F.	820	820
Catalyst Inlet Temp., °F.	1050	1050
Average Reactor Temp., °F.	900	920
Space Velocity, Total Feed, V/Hr/V	1.0	1.1
Catalyst to Total Feed Ratio, Vol.	4.7	4.7
Steam, Percent Wt. Total Feed	0	0
Pressure, psig	10	10
Recycle to Fresh Feed Ratio, Vol.	.....	1.36
Recycle:		
Gravity, °API	.....	29.4
Boiling Range, °F.	.....	345-520
Yields on Fresh Feed:		
Heavy Fuel Oil, Percent Vol.	3.5	5.1
Light Fuel Oil, Percent Vol.	27.2	.....
325-450 °F., Percent Vol.	32.0	.....
C_3 Free 291° F. @ 90 Percent, Percent Vol.	17.0	47.7
Total C_3's, Percent Vol.	5.0	10.0
Total C_4's, Percent Vol.	12.0	19.0
Dry Gas, Percent Wt.	7.5	16.5
Coke, Percent Wt.	3.4	9.6
C_3 Free Liquid Recovery, Percent Vol.	96.7	81.8
Light Hydrocarbons:		
NC_3, Percent Vol.	0.8	0.9
IC_3, Percent Vol.	3.0	7.1
C_3=, Percent Vol.	1.2	2.0
Total, Percent Vol.	5.0	10.0
NC_4, Percent Vol.	2.0	3.1
IC_4, Percent Vol.	5.9	12.4
C_4=, Percent Vol.	4.1	3.5
Total, Percent Vol.	12.0	19.0
C_3, Percent Wt.	2.3	5.1
C_3=, Percent Wt.	2.7	3.3
C_2 + Lighter, Percent Wt.	2.5	8.1
Total, Percent Wt.	7.5	16.5
10 RVP Motor Gasoline, 291° F. @ 90 Percent Yield, Percent Vol. Fresh Feed	23.3	.....
Octane Numbers	CFRM	CFRR
0 cc TEL	79.5	93.8
3 cc TEL	86.0	99.0

Stock	Gas Oil Charge	1-Pass Catalytic Treater Charge	7-RVP Base Stock	Grade 115/145 Aviation Gasoline
Yield, Based on Gas Oil Chg., Percent Vol.	100.0	32.0	20.7	72.4[1]
Properties:				
Gravity, °API	32.8	35.5	49.7	66.9
RVP	.....	.....	6.9	7.3
Accelerated Gum, Mgs/100 ml	.....	.....	2.0	.....
Aromatics, Percent Vol.	.....	.....	60.2	.....
Aniline Point, °F.	139	.....	.....	.....
Sulfur, Percent Wt.	0.45	.....	0.022	.....
Distillation, ASTM, °F.:				
IBP	379	323	99	100
10 Percent	450	355	151	125
50 Percent	509	397	251	215
90 Percent	607	435	291	255
EP	656	451	320	295
Octane Ratings:				
F-3 + 4.6 cc TEL AN Performance No.	.....	.....	100.0	115.0
F-4 + 4.6 cc TEL	.....	.....	.....	iso+2.81
F-4 AN Performance No.	.....	.....	.....	145.2
F-4 Blending Index (AGAG)	.....	.....	168.4	.....

[1] Represents blend of 29 percent base stock plus 71 percent alkylate. The octane ratings of the 7 RVP alkylate are 106.3 (F-3) Blending Octane No. and 138.9 (F-4) Index No.

1) TCC cracking 15,000 barrels daily of virgin wide-cut gas oil.
2) TCC cracking 10,000 barrels daily of virgin heavy gas oil.
3) TCC cracking 10,000 barrels daily of virgin heavy gas oil and 5000 barrels daily of TCC heavy recycle gas oil.
4) TCC cracking 10,000 barrels daily of virgin heavy gas oil, 1180 barrels daily of coker gas oil and 3820 barrels daily of TCC recycle heavy gas oil.
5) TCC processing 27,750 barrels daily of deasphalted whole crude.

For Cases 1 to 3, the refinery comprises facilities for crude topping through kerosine or No. 2 fuel oil, TCC feed preparation by tar separation and vacuum flashing, TCC cracking, visbreaking the vacuum tar, catalytic reforming the heavy naphtha and catalytic polymerization. A 10-RVP yield of 95.3 percent volume at 95 leaded F-1 octane number was assumed for catalytic reforming. In Case 4, coking is substituted for visbreaking to minimize the yield of residual fuel. The principal refinery products are 10-RVP motor gasoline—89.8 octane number (70 percent regular grade of 88 octane number and 30 percent premium grade of 94 octane number with lead contents not exceeding 2.2 cc per gallon), kerosine, No. 2 fuel oil and residual fuel. Case 5 represents an operation projected for refineries where it is desirable to hold the types of processing equipment to a minimum. This scheme involves only TCC and catalytic polymerization units. The products produced are motor gasoline, No. 2 fuel oil and heavy fuel oil. This type of operation is somewhat restricted with regard to octane level compared with Cases 1 to 4 involving catalytic reforming since only mild reforming of the straight-run naphtha occurs in the TCC unit. However, the high ratio of catalytic cracking to crude results in a high yield of good quality gasoline. A summary of the refinery yields for these five cases is shown in Table 11.

The liquid recoveries, with excess C_3's and C_4's included as LPG, range from 99.1 to 100.6 percent volume for the various schemes. The kerosine yield was maintained constant at 10 percent volume except in Case 5. The yields of other major products varied as follows:

Case 1, a refinery gasoline yield of 55.2 percent volume is obtained for once-through TCC processing the wide-cut gas oil in a 15,000-barrel-daily unit with a carbon-burning capacity of 7500 pounds per hour. This gasoline requires only 1.1 cc TEL per gallon to meet the refinery octane number specification of 89.8. The No. 2 and residual fuel oil yields are 14.0 and 15.8 percent volume, respectively.

Case 2, with a 10,000-barrel-daily TCC unit for once-through processing the heavy gas oil, gives a gasoline yield of 43.5 percent volume with a lead requirement of 1.9 cc TEL per gallon. The high lead requirement for this case is due to the lower percentage of catalytic gasoline in the refinery product. The No. 2 and residual fuel oil yields for this case are 26.0 and 17.4 percent volume, respectively.

In *Case 3*, the catalytic gas oil is processed with a recycle to fresh feed ratio of 0.50 in a 15,000-barrel-daily unit. Recycle cracking increases the refinery gasoline to 49.9 percent volume (1.3 cc TEL per gallon). The yield of residual fuel oil is decreased to 9.3 percent volume while the yield of No. 2 fuel oil increases to 27.1 percent volume.

In *Case 4*, a coking unit is substituted for the visbreaker and an 800° F. end point coker gas oil is processed in the TCC unit in place of some catalytic gas oil recycle. In this case the residual fuel oil yield is reduced to 1.9 percent volume on crude and the gasoline and No. 2 fuel oil yields are 51.8 and 30.8 percent volume, respectively. The refinery gasoline requires 1.4 cc TEL per gallon to meet the octane rating of 89.9.

In *Case 5*, the yield of gasoline is 60.3 percent volume on crude and has a lead requirement of 2.2 cc per gallon. In this case it would not be possible to increase the octane quality of premium gasoline much above 94 because there is only one source of gasoline, catalytic polymer, above this octane level. In all the other cases the TCC gasoline, because it is separate from the light straight-run gasoline, has a leaded (3 cc TEL) octane number of 98 to 99. The No. 2 and residual fuel oil yields for Case 5 are 14.8 and 15.9 volume, respectively.

REFERENCES

[1] C_4-free motor alkylate yield, percent volume, is calculated as 172 percent of the available C_4 = by volume.

[2] 10-RVP catalytic polymer yield, percent volume, is calculated as the sum of 70 percent of the C_4 = by volume and 50 percent of the C_3 = by volume.

TABLE 8

Comparison of Commercial and Pilot Plant TCC Yields at the Same Operating Conditions

CHARGE STOCK	JACKSON GAS OIL		MID-CONTINENT WIDE CUT GAS OIL	
Unit	Commercial No. 1	Pilot Plant	Commercial No. 3	Pilot Plant
Yields, on Fresh Feed:				
Heavy Fuel Oil, Percent Vol.	7.5	7.0	9.2	13.6
Light Fuel Oil, Percent Vol.	45.9	46.5	35.9	31.4
C_5 Free Motor Gasoline, Percent Vol.	35.0	35.3	42.5	42.1
Total C_4's, Percent Vol.	11.0	11.0	11.1	11.5
Dry Gas, Percent Wt.	4.9	5.3	5.6	5.8
Coke, Percent Wt.	2.0	2.2	3.5	3.6
C_5 Free Liquid Recovery, Percent Vol.	99.4	99.8	98.7	98.6
Light Hydrocarbons:				
NC_4	1.2	1.6	2.0	1.7
IC_4	5.8	6.2	4.5	5.3
C_4 =	4.0	3.2	4.6	4.5
Total	11.0	11.0	11.1	11.5
C_3	1.2	1.6	1.4	1.3
C_3 =	2.2	2.2	2.0	2.1
C_2 + Lighter	1.5	1.5	2.2	2.4
Total	4.9	5.3	5.6	5.8
10 RVP Motor Gasoline:				
Yield, Percent Vol. Fresh Feed	37.4	37.4	4.50	44.6
F-1 + 0 cc TEL			87.9	87.5
F-1 + 3 cc TEL	96.6	95.6	95.7	95.5

TABLE 11

Summary of Refinery Processing Schemes

SCHEME No.	1	2	3	4	5
TCC Charge Stock	Wide Cut Gas Oil	Heavy Gas Oil			Deasphalted Crude
Cut on Crude, Percent Vol.	42.5 to 92.5	59.2 to 92.5			0 to 92.5
Process Equipment:					
TCC, B/D Virgin Feed	15,000	10,000	10,000	11,180[3]	27,750
B/D Recycle			5,000	3,820	
Coke Burning Capacity, Lb./Hr.	7,500	5,000	7,500	7,300	12,500
Visbreaker, B/D Virgin Feed	2,250	2,250	2,250		
Coker, B/D Virgin Feed				2,250	
Yields Based on Crude:					
10-RVP Motor Gasoline,[2] Percent Vol.	55.2	43.5	49.9	51.8	60.3
Kerosine, Percent Vol.	10.0	10.0	10.0	10.0	
No. 2 Fuel Oil, Percent Vol.	14.0	26.0	27.1	30.8	14.8
No. 6 Fuel Oil, Percent Vol.	15.8	17.4	9.3	1.9	15.9
Excess B-B Stock, Percent Vol.	3.2	1.8	2.3	2.3	5.6
C_4's After Cat-Poly, Percent Vol.	2.2	1.5	2.0	2.3	3.1
Total	100.4	100.2	100.6	99.1	99.7
Refinery Fuel Gas,[1] FOE, Percent Vol.	2.8	1.7	2.4	2.9	3.7
Coke Product, Percent Wt.				2.3	
F-1 Octane Nos. of 10-RVP Gasoline:					
Clear	83.5	80.8	82.9	82.7	79.9
+ 3cc TEL/Gal.	93.1	91.5	92.8	92.6	91.4
cc TEL/Gal. 89.8 Octane No.	1.1	1.9	1.3	1.4	2.2
No. 6 Fuel Oil, SSF @ 122° F.	50	50	150	15	50

[1] Includes 22.5 percent of the total C_3's and 5 percent of the total C_4's not recovered in gas plant.

[2] Includes 1180 barrels per day Coker gas oil.

[3] Catalytic gasolines from cases 1 to 4 have 90 percent points of 385° F. In case 5 the catalytic gasoline has a 90 percent point of 330° F. since a specification boiling range No. 2 fuel oil must be made directly off the unit.

Improved Process Polymerizes Olefins for High-Quality Gasoline

Polymerization of light olefins is aided by a phosphoric acid-on-quartz catalyst. The polymer is a 98-octane gasoline

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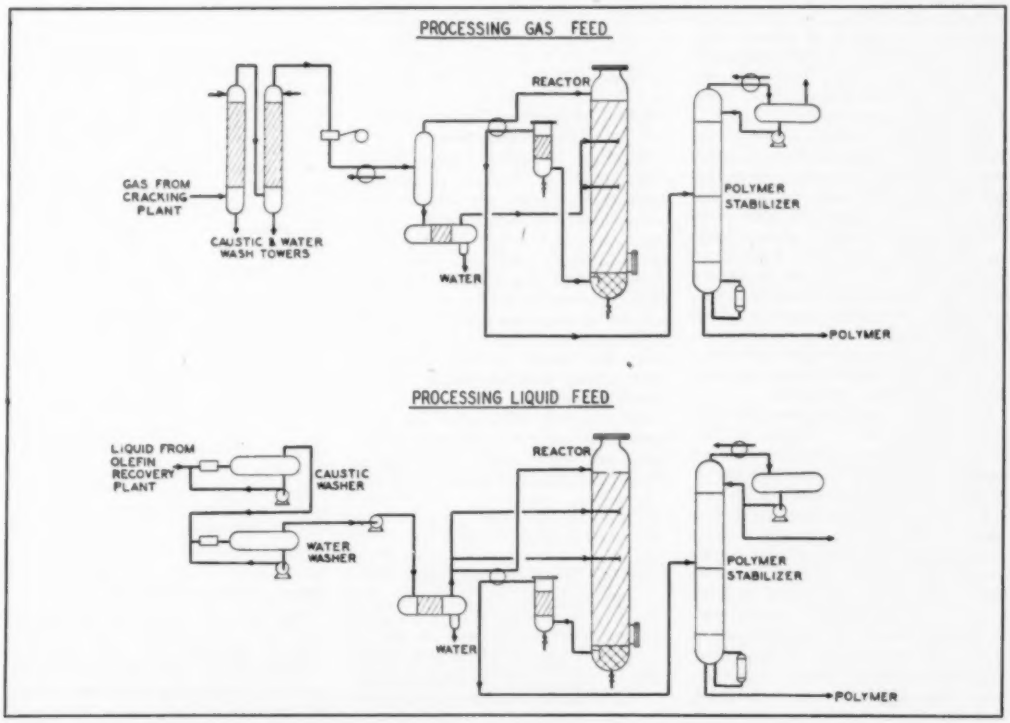
AN IMPROVED catalytic polymerization process is being licensed for the production of high quality gasoline from light olefins. The process was developed by the Research and Development Department of the Standard Oil Company of California in the early 30's, with the first commercial unit placed on stream in 1937. The results of extensive pilot unit investigations of process variables plus thirteen years of operating experience are reported in this paper.

Important features of the improved process are the use of fine-mesh quartz to minimize reactor volume, and the use of feed quench for temperature control. These features, added to those inherent in the use of the film type of catalyst — such as simplicity of catalyst preparation, avoidance of mechanical deterioration, and ease of regeneration—result in a process claimed to have exceptionally low investment and operating costs.

An outstanding feature of the process is the catalyst which is easily prepared in place in the reactor by soaking fine crushed quartz with commercial phosphoric acid of 70-85 percent concentration, and draining. The residual thin film of liquid phosphoric acid wetting the surface of the quartz is concentrated to polymerizing strength by contact with the hot feed. Because of the high mechanical strength of the quartz, no difficulty is encountered with physical deterioration of the catalyst. The accidental introduction of excess water causes a temporary reduction in activity but results in no permanent damage to the catalyst.

The catalyst can be used without difficulty over extreme ranges of temperature, pressure, water content and

Figure 1. Schematic Flow Diagram for the Process.



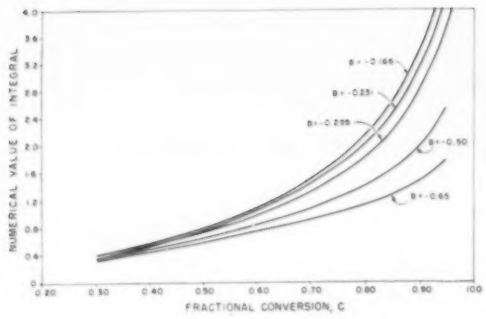


Figure 2. Value of Integral as Function of Fractoinal Conversion.

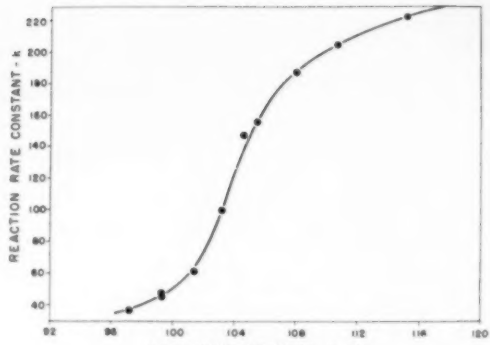


Figure 3. Effect of Acid Concentration on Catalyst Activity.

feed composition. Shutdowns have no harmful effects. Indeed, one commercial plant was operated for some time on an intermittent basis whenever olefin feed in excess of the capacity of an alkylation plant was available. Catalyst life during this period was entirely satisfactory. Because ammonia and amines are catalyst poisons, they must be carefully removed from the feed and this is accomplished by water washing. In the first plants constructed, small guard chambers filled with catalyst were included to remove any residual poisons in the feed. However, commercial experience proved this to be unnecessary. With proper feed purification it is possible to obtain long catalyst life. A life of 140 gallons of polymer per pound of 75 percent acid was obtained over a number of years of commercial operation.

Regeneration of the catalyst is as simple as its preparation and consists essentially of water washing the quartz and recoating with acid. To be on the safe side, this water washing was initially extended over about three days. However, commercial experience showed this interval to be excessive, and with the current schedule, a regeneration including depressuring purging, water washing, drying, recoating, draining and returning to service is completed in 24 hours using only regular operating personnel.

Schematic flow diagrams for the process are shown in Figure 1. The process is equally applicable to a feed such as the total gas from a thermal or catalytic cracker, or a condensed liquid C_3-C_4 cut derived from cracking operations. In both cases, a light hydrocarbon stream containing olefins is pretreated for removal of nitrogen and sulfur compounds and passed to a reactor containing the phosphoric acid on quartz, where the polymerization occurs. Provision must be made for temperature control. This is usually accomplished by the use of cold liquid feed quench. The reaction mixture is passed through a limestone-packed knockout drum to remove traces of entrained acid, and then to a stabilizer column.

Inspections of a typical motor gasoline polymer made from a feed containing mixed C_3-C_4 olefins are given below:

Gravity, °API	62.9
Reid Vapor Pressure, psi	7.3
Sulfur, Weight Percent	0.01
Octane Numbers	
F-1 Clear	98.0
F-2 Clear	84.0
ASTM Distillation, °F.	
IBP	97
10 %	162
30	226
50	248
70	280
90	359
E.P.	392

Effect of Process Variables on Rate of Reaction

The rate of olefin polymerization over phosphoric acid on quartz is a function of pressure, temperature, feed composition, acid concentration, quartz particle size and catalyst age. The process is operable over wide ranges of all these variables, and a full knowledge of the effect of each is necessary in order to select the optimum operating conditions for any particular situation. The effects of these variables were studied and the results are discussed below.

For propene, *n*-butene or any mixture of the two, the dependence of olefin conversion on feed rate can be expressed satisfactorily by the equation

$$\int_0^c \frac{(1+Bc)^2\,dc}{(1-c)^3+0.3c\,(1-c)} = \frac{k}{S} \quad . \quad (1)$$

where c = fractional conversion of monomer, moles per mole
S = space rate in gas volumes at reactor temperature and pressure per volume of catalyst voids per hour, $hrs.^{-1}$ (void volume is assumed to be 42 percent of the bulk volume)
k = specify reaction rate constant, $hrs.^{-1}$
B = fractional increase in the number of moles per unit mass for complete reaction of the monomer, i.e.

$$B = N_m\left(\frac{M_m}{M_p} - 1\right) \quad . \quad . \quad (2)$$

where N_m = mole fraction monomer in the feed
M_m = molecular weight of monomer
M_p = molecular weight of polymer

Equation (1) was obtained empirically by modifying a rate equation derived by assuming a particular reaction mechanism. The modifications were considerable and hence the final equation has no substantial theoretical significance and must be considered to be merely an empirical representation of the rate data. The specific reaction rate constant, k, is a function of the temperature, composition of the feed, acid concentration and quartz particle size, and its value must be determined for each particular situation before this equation can be used to obtain explicit values of the conversion corresponding to a given feed rate. The effects of these variables on the rate constant were determined and as a result the value is known for a wide range of reaction conditions. For convenience in its use, the integral in Equation 1 was evaluated as a function of conversion for several different values of *B* and these are plotted in Figure 2. Inclusion of isobutene in the feed alters the space rate-conversion curve and Equation 1 is not valid for feeds containing isobutene. The effect of isobutene on rate will be considered in more detail in a later section.

Effect of Acid Concentration

The rate of olefin polymerization over phosphoric acid is a sensitive function of the acid concentration. In general, it is desirable to operate with an acid containing less water than

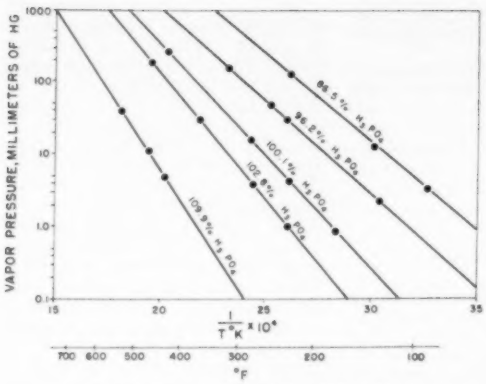


Figure 4. Vapor Pressure of Phosphoric Acid.

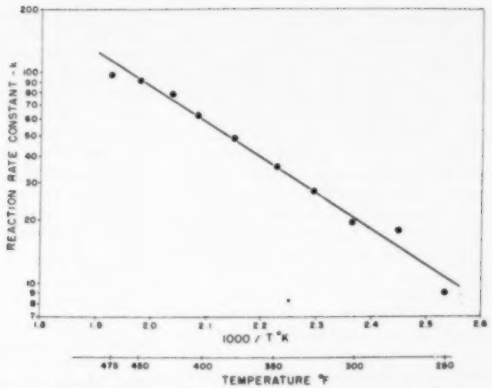


Figure 5. Effect of Temperature on Reaction Rate Constant for Propene Polymerization.

ortho-phosphoric acid. Such acid compositions are complex equilibrium mixtures of ortho-, pyro-, and meta-phosphoric acids with perhaps other molecular species. We prefer to express the acid concentration in terms of the water content on a percent H_3PO_4 scale where

$$\% H_3PO_4 = \frac{\text{weight of phosphoric acid in sample if all phosphorus were present as } H_3PO_4}{\text{actual weight of sample}} \times 100$$

On this scale, for example, pyrophosphoric acid would be designated at 110 percent H_3PO_4. This is a convenient scale in analysis, because it is customary to dilute an acid sample with water, hydrolyze to orthophosphoric acid and determine the quantity of orthophosphoric acid by titration. The percent H_3PO_4 as defined above is then obtained directly. The above definition applies to systems containing only phosphoric acids and water.

The variation of the reaction rate constant in Equation (1) with acid concentration was determined over the region from 97 to 115 percent H_3PO_4 and the results are shown in Figure 3. As shown thereon the reaction rate constant increases rapidly with increasing concentration, especially in the region from 100 to 108 percent H_3PO_4 so that the control of this variable is very important to proper plant operation. Acid of any particular concentration has an equilibrium vapor pressure of water; hence, it is necessary to introduce sufficient water into the reactor feed so that the partial pressure of water in the reactor is equal to the vapor pressure of the acid. The vapor pressures of several phosphoric acid compositions were determined in this laboratory and are shown in Figure 4. To achieve a given acid concentration in a reactor it is necessary to determine the vapor pressure of acid of that concentration at the operating temperature from Figure 4 and introduce the appropriate amount of water into the feed. This water is usually introduced as water of solubility by washing the feed at the appropriate temperature but may be introduced as liquid or as steam into a dried feed.

As far as catalyst activity is concerned, it would be desirable to operate at as high an acid concentration as possible. The effect of acid concentration on rate of catalyst activity decline is not accurately known, but there are qualitative indications that at very high acid concentrations the rate of decline increases. It is known that acid concentrations as high as 106 percent H_3PO_4 give satisfactory catalyst life.

Effect of Pressure

The feed rate necessary to obtain a given conversion is directly proportional to the reactor pressure. This direct proportionality was demonstrated for propene polymerization over the pressure range 250 to 1800 psig and operation of the process anywhere within this pressure range is entirely feasible. This dependence of feed rate on pressure appears in Equation (1) in the value of the space rate, S, which, as defined, is a function of pressure.

In order to obtain this increase in space rate with increased pressure, a constant acid concentration must be maintained. Therefore, if the pressure is increased, it is necessary to reduce the water content of the feed in order to hold a fixed partial pressure of water vapor in the reactor. When operating under conditions where the addition of water in excess of that contained in the feed is required, the reduction in the water added to the feed is easily accomplished. Usually the water content of the feed is fixed by the solubility of water in the feed at the temperature of the water wash. In this case the increase in allowable feed rate resulting from increased pressure is in part offset by the decrease in allowable feed rate resulting from decreased acid concentration. For operation at higher pressures, feed driers can be installed but this is usually not justified economically. For most refinery situations the minimum plant cost is realized at an operating pressure in the region of 200 to 500 psig.

Effect of Temperature

The effect of temperature on the rate of reaction of propene was studied over the region of 250 to 475° F. and the results are shown in Figure 5 where the reaction rate constant is plotted versus the reciprocal of the absolute temperature. This chart shows that the temperature coefficient is not large and that the reaction rate approximately doubles with a temperature increase of 70° F. In order to avoid an excessive rate of catalyst activity decline, operation above 400° F. is generally not recommended. In the majority of cases, operation in the region from 300 to 400° F. is optimum.

Effect of Quartz Particle Size

In a catalytic reaction of this kind, it is to be expected that the rate of reaction would be directly proportional to the area of exposed catalyst surface. The area of a given mass of non-porous spherical particles is direcly proportional to the reciprocal of the diameter, and this relationship is approximately true for irregularly shaped particles reasonably uniform in size. Therefore, it would be expected that a plot of the reaction rate constant versus the reciprocal of the

average particle diameter would be a straight line. Figure 6 shows that this is the case over a considerable range of particle size; however, pronounced deviations occur as the particles become very small. This deviation probably results from the fact that the thickness of the acid film on the particles becomes appreciable with respect to the size of the interstices so that the assumptions of the constancy of void volume and of the proportionality between quartz particle diameter and surface of acid exposed are no longer correct.

It would be desirable to use very small quartz particles in order to obtain the maximum catalytic activity. Other considerations, such as pressure drop, limit the practical range so that, in general, it is not desirable to use a size smaller than 28 to 35 mesh.

Effect of Feed Composition

Of the C_3-C_4 olefins, propene reacts the most slowly, *n*-butene reacts at about twice the rate for propene, while isobutene reacts very much faster than either. The reaction rate constants for propene, *n*-butene and mixtures of the two were determined and are plotted in Figure 7. The rate of reaction of mixtures of *n*-butene and propene is a linear function of the *n*-butene content. The rate of reaction of isobutene was not studied separately but in mixtures with the other C_3-C_4 olefins it has the effect of accelerating the rate considerably, especially in the low conversion region. The character of this effect is shown in Figure 8 where the feed rate-conversion curves are plotted for two feed stocks containing isobutene. Also shown are the corresponding curves for feeds containing the same ratio of propene to butene but containing no isobutene. For a particular initial concentration, the effect of isobutene on rate is large at low conversions and diminishes as the conversion increases. It is also apparent that at any particular conversion level the effect of isobutene on rate is not a linear function of the initial isobutene content and that its effectiveness is greater at low concentrations.

The feed rate to achieve a given conversion increases with increased mole fraction of olefin in the feed but this effect on rate is small. In Equation (1) the olefin concentration in the feed appears only in the value of the shrinkage factor *B*. The reaction is, therefore, essentially first order with respect to monomer.

Effect of Reaction Variables on Product Quality

The character or properties of the polymer product are little affected by variation in reaction conditions within the normal operating region. The octane number of the motor polymer is essentially constant over the entire operable region. The boiling range of the polymer varies somewhat with reaction conditions but the changes are usually minor. Directionally, increased temperature and pressure result in a lower boiling polymer. Variation of the acid concentration over the range from 100 to 108 percent does not appreciably change the character of the polymer. Propene polymer is usually higher boiling than is butene polymer and the average molecular weight of the polymer decreases somewhat as the catalyst declines in activity.

Plant Design Considerations

Feed Preparation

Light olefins for polymer plant feed stock are usually derived from hydrocarbon cracking processes, thermal and/or catalytic, and are produced as gaseous products from the naphtha recovery system of the cracking plant. With the advent of increased utilization of the normally gaseous hydrocarbons it is often found advantageous in modern refinery installations to fractionate and recover the propane and butane fractions free of the associated lighter hydrocarbons. In either case the polymer plant feed stock usually requires treatment to remove sulfur and nitrogen compounds. Sulfur in the form of hydrogen sulfide and mercaptans must be removed in order to produce a polymer low in sulfur content. This is accomplished by washing the feed stock with a solution of caustic. In the case of high hydrogen sulfide content, it may be economical to employ one of the regenerative-type hydrogen sulfide removal processes followed by a caustic wash to remove mercaptans. Ammonia or organic amines must be removed because they exert a poisoning effect on the catalyst greatly in excess of their neutralization capacity for phosphoric acid. These compounds, being water soluble, are removed by a water wash. Because the catalyst activity is an inverse function of the water content of the feed, it is desirable to conduct the water wash at as low a temperature as possible and to avoid the entrainment of water in excess of the equilibrium concentration.

Reactor Design

Polymerization reactors are of two types; chamber and tubular. The chamber type consists of a vessel packed with catalyst and since it is essentially adiabatic the exothermic heat of reaction raises the temperature of the hydrocarbons to an extent determined by the enthalpy of the reactants and products. The tubular type consists of a vertical bundle, the tubes of which are packed with catalyst with the shell side containing a cooling medium which removes the heat of reaction by heat exchange through the wall.

Owing to a number of economic factors, among them being the alloy construction involved, it has been found advantageous to use chamber type reactors in commercial installations. Tubular type construction is inherently more complex. The chamber type reactor consists simply of an alloy lined vessel with no internal members other than alloy spiders embedded in the quartz for distribution of quenching medium. A supporting grid for the catalyst bed is eliminated by the use of graded quartz at the bottom of the reactor vessel.

The kinetics of the polymerization reaction is influenced by temperature,

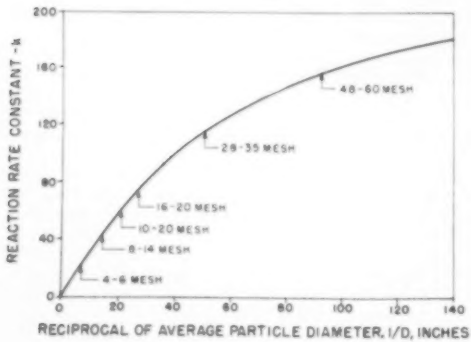


Figure 6 (left). Effect of Quartz Particle Size on Catalyst Activity.

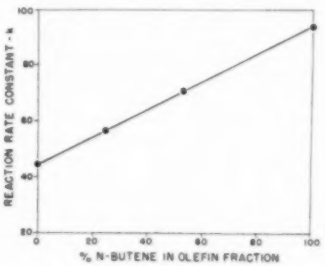


Figure 7 (right). Effect of Composition of A Propene-N-butene Fraction on Reaction Rate.

pressure, catalyst activity and olefin composition. In order to select the operating conditions for optimum plant design it is necessary to take these factors and the operating conditions of the feed preparation and polymer recovery sections into consideration.

The temperature range of 300 to 400° F. usually is the most favorable. Lower temperatures require excessive reactor volumes while higher temperatures reduce catalyst life.

Because reactor volume is inversely proportional to pressure, an economic balance must be made to determine the optimum reactor pressure. Factors to be considered are equipment cost, operating cost and reactor on-stream time. The reactor operating factor (fraction of time on-stream) decreases with increasing pressure because the weight of catalyst in the reactor determines the on-stream time and the volume of catalyst required becomes smaller with increasing pressure. A reactor pressure of 200 to 500 psig is usually found to be the most favorable. The minimum operating pressure is fixed by the operating pressure of the polymer stabilizer.

Catalyst activity is a function of the concentration of the phosphoric acid which in turn is fixed by the temperature and the partial pressure of water in the reactor (neglecting for the moment the decline in activity due to aging of the catalyst). Because both temperature and partial pressure of water vary through the reactor the phosphoric acid concentration must be calculated at a number of points in the reactor and an integrated catalyst activity obtained therefrom for use in sizing the reactor. The amount of water in the reactor feed is usually fixed by the solubility of water in the feed at the temperature of the water washing operation. It is possible, of course, to dry the feed by chemical means and obtain a higher catalyst activity, but the installation and operating costs of the dryers usually outweigh the reduction in reactor size thus gained.

Catalyst activity is also a function of the size of the quartz carrier as shown in Figure 6. Early commercial installations utilized 10 to 20-mesh quartz, whereas current design practice calls for the use of 28 to 35-mesh quartz. This change results in almost two-fold increase in catalyst activity, permitting reduction in reactor volume to half that formerly used.

The composition of the olefins in the feed stock has a marked effect on the reaction rate. Reactor size for a given overall conversion is determined by the rate equation using a rate constant fixed by the composition of the olefins. Feed stocks usually contain olefins in amounts such that if they were allowed to react adiabatically to 90 percent conversion the temperature rise would be considerably in excess of the desired 100° F. The temperature rise can be limited to the desired range by one of three methods: 1) a portion of the stabilizer overhead product which is low in olefins can be recycled to the reactor feed in order to reduce the olefin content so that the temperature rise through the reactor is limited to 100° F. This method has the disadvantage that both the reactor and stabilizer must be made larger, thus increasing the operating expense because of the large recycle stream required; 2) the amount of stabilizer recycle can be reduced significantly by using it as a liquid quench at suitable levels in the reactor, in a number of beds each of which is limited to the desired temperature rise; 3) a further economy in equipment size and operating cost can be achieved by use of the cold feed itself as the quenching medium. Thus, the incremental equipment and operating costs for recycling stock from the stabilizer can be eliminated. The quench is distributed at the various levels in the reactor by spiders embedded in the quartz.

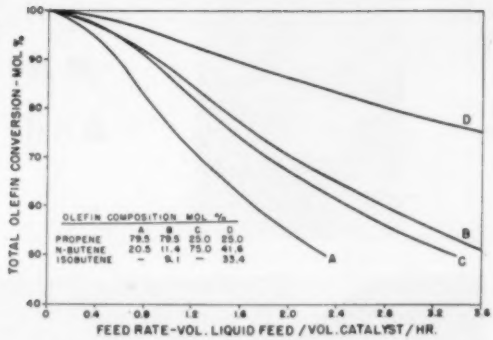


Figure 8. Effect of Isobutene on Reaction Rate.

Catalyst Preparation and Regeneration

The reactor is packed with 28 to 35-mesh quartz using graded quartz at the bottom of the vessel to provide support for the main catalyst mass. The catalyst is activated initially simply by pumping the reactor full of 75 percent phosphoric acid, draining the acid back to storage and activating the catalyst by passing hot feed through the reactor. The feed-reaction mix exchanger is manifolded for use as a steam heater during the startup period. As the film of phosphoric acid on the quartz becomes concentrated it acquires polymerization activity. During the first few days of operation with fresh catalyst, approximately 40 percent of the acid initially retained in the quartz drains to the bottom of the reactor. This acid is withdrawn to storage as it accumulates.

A small knockout drum packed with ¾-inch lump limestone is used to remove any traces of entrained acid in the reactor effluent. The limestone which neutralizes the phosphoric acid has been found to have a life in excess of one year. Corrosion problems in the use of phosphoric acid have been solved by the use of commercially available stainless steels in the reactor section.

When the catalyst activity has declined to the point where regeneration is required, the reactor is taken off stream and the activity restored by the following steps. Approximate time for each step is shown:

1)	Release pressure and vent reactor	1 hour
2)	Fill with cold water and drain twice	3
3)	Fill with hot water (280 to 300° F) and continue to pump through the reactor to the sewer	4
4)	Pressure with steam to 120 psig draining condensate as it forms	4
5)	Release reactor to atmospheric pressure to evaporate most of the condensate wetting the hot quartz	½
6)	Evacuate to 4 psia to complete the evaporation of condensate	2
7)	Fill with 75 percent H_3PO_4	3
8)	Drain acid back to storage	5
9)	Return reactor to service	1½
		24 hours

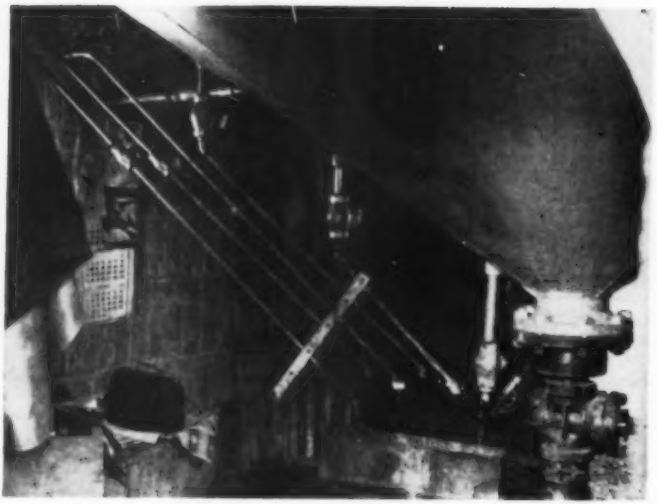
An attractive feature of the process is the ease with which the catalyst can be regenerated with regular operating personnel.

Conclusion

Important features of the improved process are the use of fine mesh quartz to minimize reactor volumes and use of feed quench for temperature control. These features, added to those inherent in use of the film type of catalyst such as simplicity of catalyst preparation, avoidance of mechanical deterioration and ease of regeneration, result in a process having exceptionally low investment and operating costs.

MAINTENANCE And OPERATION

How To Do It—



Centralizing Sample Line Outlets

SAVINGS in an operator's time can be afforded by the centralization of sample line outlets. A particular application is on a cone-bottomed treating tank where samples must be taken at various tank levels. The sample lines are connected to the shell of the vessel in the usual manner where sample cocks are installed at a convenient height. With the use of 45° ells, the sample lines are run to a common point above the funnel leading to the sewer. The loose pipe ends are held in place by a spreader bar.

Deflector Shield For Fog Nozzle

IN PRACTICE oil fire fighting at one plant, it was observed that fog nozzle spray directed against the oil surface caused agitation of the oil due to the fact that the lower part of the stream was striking the surface at a sharp angle and at a high velocity. Such agitation facilitates burning and hinders effective fire fighting. To remedy this defect, a metal shield was welded to the nozzle as shown in the drawing.

When fighting a fire on an exposed liquid surface, the nozzle is held with the shield on the bottom side. As the fire fighters approach the burning liquid from a low angle, the deflected stream from the nozzle sweeps across the surface to force the fire into smaller area. This permits the spray from the top side of the nozzle to cool the liquid and extinguish the flame.

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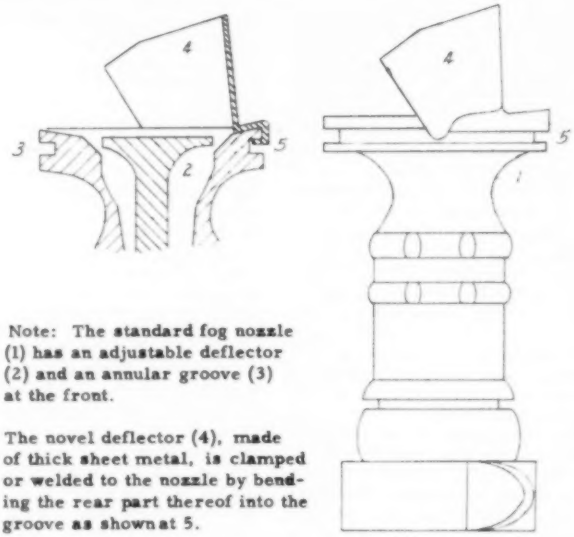
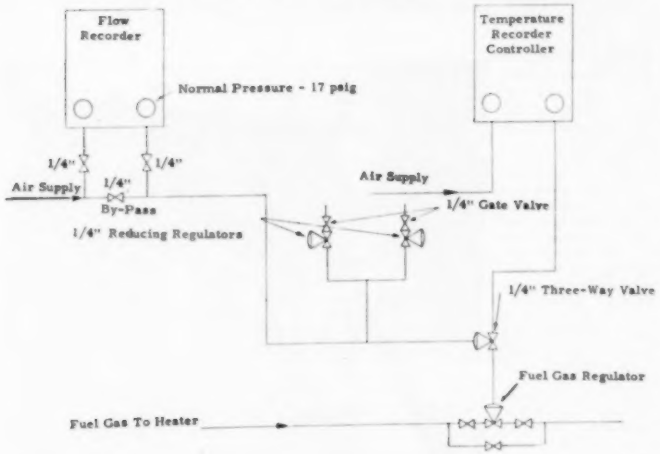


Note: The standard fog nozzle (1) has an adjustable deflector (2) and an annular groove (3) at the front.

The novel deflector (4), made of thick sheet metal, is clamped or welded to the nozzle by bending the rear part thereof into the groove as shown at 5.

Shutdown Device for Minimum Heater Flow



WHEN oil flow through direct fired heaters stops abruptly excessively high pressures and temperatures are created within the oil tubes unless the fire is cut out of the fire box immediately. The hazard of rupturing tubes and thereby starting serious oil fire is greatly increased under these conditions. An automatic minimum flow shut-down device has been made to protect these heater tubes from such occurrence.

The hook-up is as shown on the attached drawing. The original installation on the heaters consisted of a discharge oil temperature recording controller operating the heater fuel gas regulator and a flow recorder measuring oil flow through the heater. With these instruments in place, it was necessary to buy only a ¼-inch three-way, diaphragm-operated, direct-acting valve, two ¼-inch reducing regulators, and an on-off control unit for the flow recorder to make the automatic shut-down installation. The three-way valve was placed in the controlled air line between the temperature recorder controller and the fuel gas regulator. The two reducing regulators were connected in reverse and in parallel on the contolled air line between the flow recorder and three-way valve diaphragm. The on-off control unit was then installed in the flow recorder instrument.

In use, the index pointer on the flow recorder was set at a point slightly below normal recorded flow. As long as the oil flow remains normal, full instrument air supply pressure is transmitted by the flow recorder to the three-way diaphragm valve, allowing it to stand open. Controlled air flow from the temperature controller to the fuel gas regulator is therefore not interrupted. When oil flow stops, the indicator pen on the flow recorder drops below the index pointer and trips the flapper away from the nozzle which bleeds the air pressure from the line supplying the three-way diaphragm valve. The two ¼-inch reducing regulators (installed in reverse) are set to open to the atmospheric when line pressure drops to 10 psig.

This provides additional means for venting the controlled air from the line between the flow recorder and the three-way valve to atmosphere. As the controlled air pressure drops below 10 psig., the three-way valve closes off the controlled air flow from the temperature controller to the fuel gas regulator. Simultaneously a bottom port in the three-way valve is opened and vents air from the line between this valve and the fuel gas regulator diaphragm. The fuel gas regulator then closes and fire is extinguished in the fire box. If the oil flow is re-established to normal in a short time, the flapper again covers the nozzle and allows controlled air to flow toward the three-way valve. This air pressure would open the three way valve and consequently the fuel gas regulator if allowed to build up. Since it is desirable that the heaters not be fired up until the operator so desires, the air pressure is bled to the atmosphere from this line through the two reducing regulators. Caution must be taken to provide sufficient bleed off capacity to prevent build up to 10 psig. Should the pressure reach 10 psig., the reducing regulators would close and allow normal controlled air to pass from the flow recorder to the three-way valve. Two ¼-inch reducing regulators are used on the installation at the plant where this device was instigated. In order to place the shut-down device back in operation after normal oil flow is resumed, the plug valve downstream of the fuel gas regulator and the one on the by-pass around this regulator must be in a closed position. The two ¼-inch gate valves downstream of the ¼-inch reducing regulators are manually closed by the operator. This permits controlled air pressure to build up again and open the three way valve. This allows the controlled air to flow to the fuel gas regulator. The plug valve downstream of the regulator is opened and the heaters lighted. Normal service is thus established.

When it becomes necessary to reduce the oil flow to a heater by stopping one of the two pumps in this service, the automatic shut down mechanism must be taken out of service to prevent completely cutting off the fuel gas supply to the heater. This may be accomplished by opening the by-pass between the air supply and controlled air lines on the flow recorder instrument, thereby maintaining the three-way valve in open position.

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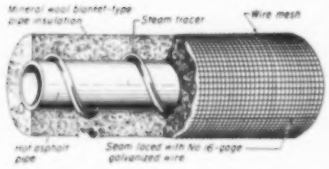
Maintenance and Operation Ideas
Are Worth Money.
Send your HOW TO DO IT suggestions with photos or sketches to Editor, Petroleum Refiner, Box 2608, Houston, Texas.

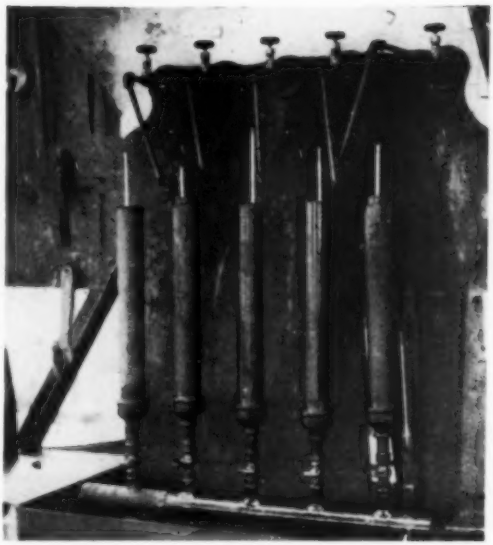
"Deflector Shield For Fog Nozzle" on the preceding page, this item, and "Liquid Level Gauge From Salvaged Parts" on the following page are prize winning "Operation Kinks" from the Panhandle Plains Regional Meeting of NGAA, Amarillo, Texas, November 20, 1951.

Insulating Spirally Traced Lines



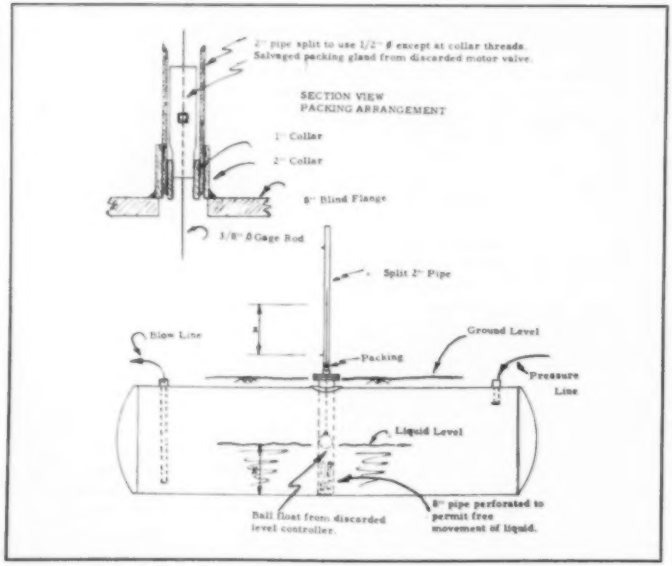
MANY plant engineers have found that blanket-type mineral wool solves such troublesome installation problems as the insulation of asphalt pipe lines heated by spirally-wrapped steam tracers. To insulate the spirally-traced pipe in the sketch, each section of blanket-type mineral wool insulation is roughly shaped to fit over the asphalt pipe and tracer. The edges of all sections are tightly laced together with 16-gauge galvanized wire, with longitudinal seams located on the underside of the pipe. Exposed ends of the lacing wire are bent over into the insulation to elminate sharp projections.

Permanent Gravity Station



BREAKAGE of cylinders and hydrometers can be prevented by the installation of a permanent gravity station, as shown in the illustration. Lead lines from five product accumulators were conducted to a central control station, where the operator takes samples and makes gravity determinations. The lines pass through the back of a hooded case attached to a trough and waste line. Five separate cylinders stand immediately beneath the sample cocks into which hydrometers are inserted. The cylinders are set into reducers fitted with pinch cocks. All cylinders are attached to a single drain line to dispose of surplus liquid. When constructing the cylinder units, a screen was inserted in to the large end of the reducer as a cushion for the hydrometer bulb. For a gravity determination, the sample nipple is swung over the cylinder and enough liquid is permitted to flow until a representative sample is obtained. The pinch cock is then closed and the cylinder is filled until the hydrometer floats to the top.

The permanent station also facilitates the task of taking laboratory control samples, since all five bottles may be filled at one station. For laboratory samples, the nipples are simply swung to the side for filling the sample bottles.


2" pipe split to use 1/2" ϕ except at collar threads. Salvaged packing gland from discarded motor valve.
SECTION VIEW
PACKING ARRANGEMENT
1" Collar
2" Collar
8" Blind Flange
3/8" ϕ Gage Rod
Split 2" Pipe
Blow Line
Ground Level
Packing
Pressure Line
Liquid Level
Ball float from discarded level controller.
8" pipe perforated to permit free movement of liquid.

Liquid Level Gauge From Salvaged Parts

TO PROVIDE a liquid level indicator in an underground sump, a gauge was fabricated from salvaged parts as shown in the sketch. An eight-inch pipe, perforated to allow free movement of the sump liquid, was inserted to the bottom of the sump and welded into position by means of a flange and pad. Alignment of the gauge rod is provided through a blind flange in which a hole has been cut. The gauge rod sleeve is provided by splitting a two-inch pipe down to the threaded nipple, which is screwed into a collar on the blind flange. With a ball float attached to the gauge rod, the remaining problem was to provide an adequate seal. This seal was accomplished through the utilization of a discarded motor valve packing gland.

—H. O. True
Phillips Petroleum Company
Crane, Texas

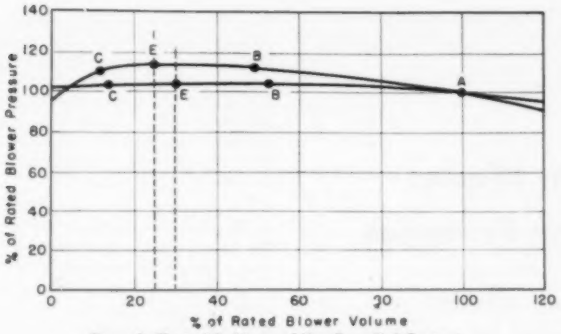


Figure 1. Chart of Problem and How Remedied. See text.

How to Cure Pulsation Problems In Centrifugal Blowers

O. W. ACHESON

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WHEN A centrifugal blower is used in the capacity range for which it was designed, pulsation is seldom a problem. There are, however, certain applications of blowers—where it is necessary to keep the blower running during periods of very small demand. In the case of certain heating processes these "turn-down" or "weekend holding" periods may call for as little as 10 or 20 percent of rated volume output of the blower. In such cases, surging can set up a pulsation which may disturb the process and cause overheating and consequent damage.

PULSATION in centrifugal blowers can be prevented—and corrected—if one understands the mechanics of pulsation and the characteristics of a centrifugal blower. The pressure-vs.-delivery curves shown in the accompanying sketch are typical of all centrifugal blowers, the upper curve being of a well designed blower, and the lower curve of a not-so-well designed blower. Note that in both cases the pressure attains a maximum high point at some relatively low rate of air output, the curve rising at air delivery rates below this critical value and descending at rates above this critical value.

If the demand on a blower is decreased in volume from a normal operating point, *A*, to another normal operating point, *B*, above the maximum-pressure point, the pressure at the blower merely rises correspondingly, and pulsation does not occur. If, however, the load or volume requirement is decreased beyond the maximum-pressure point, *E*, to a very low point, such as *C*, the following sequence of circumstances may set up surging.

The blower delivery pressure first decreases from *E* to *C at the blower itself*. Thus for a moment, the pressure in the piping system connected to the blower is greater than the pressure at the blower itself. Thus the air in the line tends to reverse its direction and flow back into the blower (this can be extremely dangerous in handling gas to a burner or combustion chamber) until both pressures become equalized. When this is achieved the blower again resumes its normal function of pumping air into the system—until the restriction at the line outlet again reduces throughput and causes the sequence to repeat.

It is this repetition which constitutes surging.

The frequency and intensity of surging depends upon: 1) the slope of the pressure-vs.-volume curve, 2) the rate at which air is being removed from the system, and 3) the volume of the pipe system to which the blower is delivering air. The same principles apply whether the centrifugal unit is operating as a blower or an exhauster.

Anticipation of Circumstances

The wisest action to take in the prevention of pulsation is the anticipation of circumstances which might cause it. The phenomenon will not occur in volumes above the point E. If the application is such that low turn-downs are expected, it is prudent to so indicate when the blower is being ordered. The blower manufacturer can, in most cases, select and specify to prevent pulsation.

If, however, pulsation or surging is noticed in a finished installation, any of four steps can be taken as follows:

1) Consider the economics of replacing the blower with a smaller capacity unit having a consequently lower surge point.

2) Consider purchasing a small capacity unit for turn-down periods.

3) Make sure that the amount of air delivered by the blower is always above the surge point by bleeding enough air out of the system beyond the blower. If you are handling gas rather than air it will be necessary to recirculate this bleed flow back into the blower inlet. If you recirculate the bleed, however, remember that you are compressing and re-compressing that portion of the gas and building up the blower temperature to a point which may be detrimental.

4) If the surging is infrequent and of short duration, it may not be harmful to the blower at all. Surging at the point of air or gas use may be eliminated by adding a surge tank or increasing the cubical content of the piping in front of the nozzle.

5) Ask the manufacturer to make minor changes in the blower design to permit by-passing of the air, or take other steps which will eliminate the troublesome pulsation at the sacrifice of a little blower efficiency or tightness of the installation.

Actually, the more efficient a blower operates and the tighter the air system is beyond the blower, the more likely it is to surge at very low operating points. Fortunately, the uses for compressed air or gas, which demand blower operation at critically low output, are infrequent so that the use of high-efficiency equipment can be used in all but the rarest of cases.

* * *

MAINTENANCE
And OPERATION

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How to Reduce Phenol in Wastes From Catalytic Petroleum Processes

Extensive study shows most efficient solvent extraction method for handling process accumulator water

PHENOLIC compounds, although tolerated to some extent by fishes, are definitely toxic. Its toxicity to fresh-water life is reported in concentrations ranging from less than one to ten ppm and in a range as low as one to two ppm. There is a strong evidence that phenol gives an undesirable taste to fish. The general thought of many is that research will establish a phenol limit of five parts to a billion for drinking water free of undesirable taste although the U. S. Public Health Service places a limit of 0.001 ppm. Phenolic materials are produced unavoidably in all refineries employing catalytic processing. The main source is the new fluid catalytic cracking operation; however, there are other sources too numerous to mention but probably not in the magnitude of this particular process.

Several methods for the treatment of phenolic wastes have been developed and are in use in many industries. An important method is the biological oxidation of the phenolic material making use of trickling filters. The phenol concentration is usually controlled between 30 and 50 ppm with the final effluent from the process containing one to three ppm. A biologiral oxidation process was developed in Germany employing a tank aeration operation using ammonium phosphate as a nutrient. This particular process reports reductions from as high as 1000 ppm to between one and ten ppm in the final effluent.

Other processes include the use of activated carbon and pulverized coal. These processes are generally used in conjunction with other methods of phenol reduction. The use of alkaline ion exchange resins is gaining in importance; however, the composition of waste governs its effectiveness. Presence of material more acidic than phenol, such as hydrogen sulfide, affect the operation of this type resin. Some refiners are using salt free phenolic wastes as make-up water in recirculation water systems utilizing the bactericide characteristic of phenols. Several refiners evaporate small volumes of phenolic wastes via furnace stack or furnace proper.

The chemical oxidation of phenols in waste waters is gaining wide recognition. Ozone, chlorine, and chlorine dioxide treatments are some commercial methods of phenol reduction by chemical oxidation. These three processes were investigated quite thoroughly on a major steel plant liquor containing ammonia and phenolic materials. The principle in each case is the direct injection of the oxidant in such quantities as to satisfy the total oxygen demand of the waste. The cost of installation of equipment and chemical needs for this type of reduction limits their extensive use throughout the petroleum refining industry.

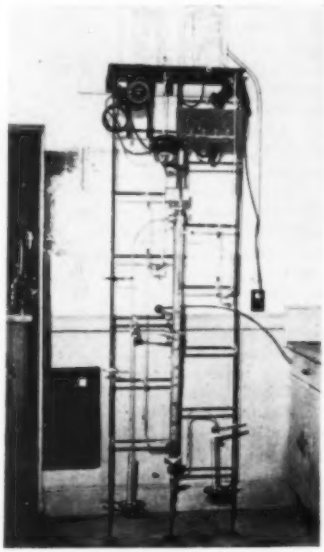


Figure 1. Laboratory extraction unit used for experimentation is equivalent to an 11-stage extractor.

The presence of certain compounds in the phenolic waste waters prevents the normal methods of phenol reduction. The process accumulator water from fluid catalytic cracking operations not only contains the undesirable phenolic materials but considerable quantities of ammonium polysulfides. These ammonium polysulfides are oxygen demanding compounds; therefore, the oxidation processes by chemical or biological means are either inoperative or not economically feasible. The oxygen demand by the sulfides must be fulfilled before the oxidation of phenols can be accomplished. The presence of sulfides in the waste waters limit the use of alkaline ion exchange resins. The large quantities of waste water from the accumulators often prevent the injection into furnace stacks or furnaces for elimination by evaporation. The injection of the sulfide bearing waste into recirculating water systems will give rise to corrosion problems as well as the accumulation of colloidal sulfur and phenols.

The treatment of such waste is limited unless the oxygen demand by the sulfides is reduced or completely eliminated. This can be accomplished by one of several methods. Among these, are two excellent methods for the elimination of sulfides; namely, the treatment of the waste with flue gas and the treatment by aeration. The flue gas containing carbon dioxide neutralizes the ammonia freeing the sulfur as hydrogen sulfide or liberation as colloidal sulfur. Aeration will accomplish a similar result; however, the formation of colloidal sulfur remains an objection to this procedure as does the neutralization of flue gas.

The need for an economical and efficient removal brought about a thorough and extensive study of phenolic material reduction methods by means of solvent extraction. The data for this study was obtained from the use of a laboratory Scheibel multistage fractional liquid—liquid extraction unit for operation with gravity feed. The principle of the extractor is countercurrent flow of solvent and waste which are mixed by motor driven paddle wheels having wire gauze settling spaces or zones between each. A mixing and settling zone is classified as one stage treatment. The model used for experimentation was considered equivalent to an 11-stage ex-

Original presentation as "Reduction of Phenol in Wastes from Catalytic Petroleum Processes" was at the Seventh Industrial Waste Conference, Lafayette, Ind., May 8, 1952.

tractor. The solvent enters near the bottom of the extractor and the phenolic waste near the top. The spent solvent leaves from the top of the extractor and the phenol reduced waste from the bottom. The separation is due to the difference in the specific gravities between the solvents and the phenolic waste water. The flow rates of both solvent and waste water are controlled by use of needle valves and rotameters; thus, the ratio of solvent to waste can be regulated as so desired. The mixing rate of speed is controlled by a powerstat connected to the motor driving the paddle wheels. A few minor alterations were made to adapt the extractor for use with the high sulfide bearing waste. A photograph of the extractor is shown in Figure 1.

The initial experiments were promising in that the presence of ammonium polysulfides had no effect upon the solvent extraction of phenolic material from the process accumulator water. After the determination of this fact, the investigation progressed as to solvent type, solvent ratios, required stages, solvent regeneration and solvent losses. These five factors determine the effectiveness and the efficiency of multi-stage extractions. A general discussion of the investigation follows.

Solvent Type

The choice of solvent was based on cost, commercial availability, specific gravity and the solvency power. Experimentation proved that mixtures of paraffin and aromatic hydrocarbons gave the desired characteristics. The higher the aromatic content the greater the efficiency of extraction. The effect of composition is illustrated with the following typical removals of phenolic materials using a single stage extraction and a 1-to-1 ratio of solvent to waste:

% Aromatics	% Phenol Removal
25	25
35	42
49	53
75	68
100	73

The paraffin and aromatic mixtures used in the experimentation were the catalytic cracked gasoline and catalytic reformed gasoline fractions blended with benzol. The aromatic contents of such blends are shown in Table 1.

TABLE 1

	% Aromatics
1) Catalytic Cracked Gasoline Fraction	25
2) Catalytic Reformed Gasoline Fraction	35
3) 66% of Number 1 34% of Benzol	49
4) 34% of Number 1 66% of Benzol	75
5) 100% Benzol	100

Although the efficiency of removal is greater for aromatics, the use of them as a solvent would present some minor problems. The gravity difference between aromatics and the phenolic waste could cause some separation difficulty; however, this would depend upon the flow-rates through the extractor and the length of time allowed for settling.

Another problem, from the use of pure aromatics, would be the loss of solvent due to solubility in water. The addition of paraffin hydrocarbons to the aromatics would reduce the solvent solubility in the waste to a very minute quantity. Figure 2 illustrates the solubility values for paraffin and aromatic hydrocarbons.

Solvent Ratios

This second factor was investigated to determine a ratio giving the greatest efficiency on the various solvent mixtures. This data is necessary and important for the design of full-scale extractors. The data obtained for the various ratios on a single stage extraction of the phenolic material from the waste water would be typical of that shown in Table 2.

It is observed that the effect of increased solvent ratios follows a solubility relationship between phenol-water and phenol-solvent; however, this relationship is different for solvent containing more or less amounts of aromatic hydrocarbons. When equilibrium is reached between a solvent containing 25 percent aromatics and an aqueous waste, the phenol concentration is approximately 2½ times greater in the waste than in the solvent; however, for a solvent containing 100 percent aromatics, the phenol concentration is approximately 2½ times greater in the solvent than in the waste.

Required Stages

A stage in this process of phenol removal is referred to as a single mixing and settling zone of the extractor. The stages are arranged so that the high phenol solvent comes in contact

TABLE 2

Percent Aromatics in the Solvent	Percent Phenol Removal with Solvent Ratios of				
	1/1	2/1	3/1	4/1	5/1
25	25	43	56	63	68
35	42	55	62	69	72
49	53	65	71	77	80
75	68	78	83	85	87
100	73	84	88	90	92

(See Figure 3 for graphs of the above).

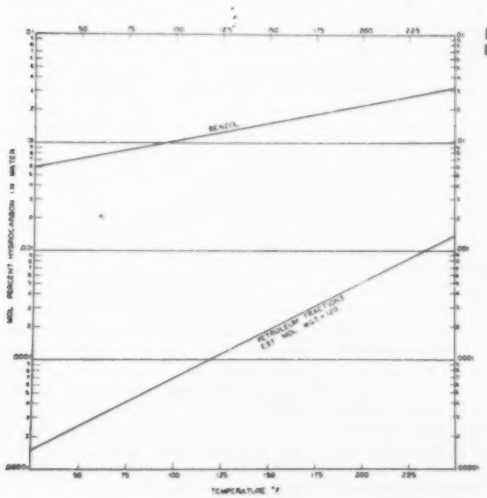
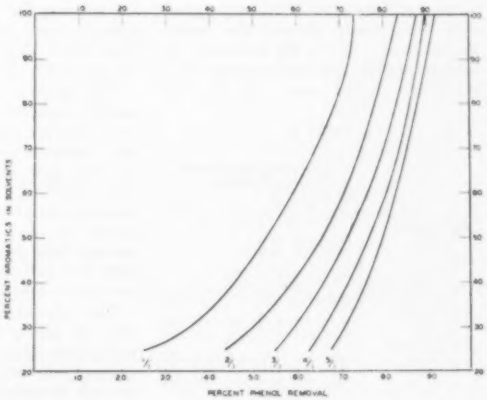


Figure 2 (left). Solubility of Hydrocarbon in Water.

Figure 3. Single-Stage Extraction, Ratios of Solvent to Waste.



with the high phenol waste and remains in such contact by regulated flow rates until equilibrium is reached. The waste continues downward through the stages coming in contact at each stage with solvent containing lesser amounts of phenol. During the last stage of the extraction, the phenol reduced waste is in contact with phenol free solvent.

The effect of additional stages was investigated so that the stage requirement could be determined for maximum efficiency. In this determination, various solvent types and solvent ratios were used for comparable data.

Table 3 data would be typical for the accumulator water from petroleum catalytic cracking operations. The waste water used in the above contained some 200 ppm of phenolic material. The application of the data to other types of waste waters with higher or lower phenolic contents is questionable; however, the trend would be of the same or of like pattern.

Solvent Regeneration

In the design of a solvent extraction process, the question of solvent regeneration is of utmost importance. Cycling of the solvent without regeneration would continuously decrease the solvency power. The regeneration of spent phenolic solvent is very simple in that a scrubbing of the solvent with a caustic solution will revivify it to the original condition. The caustic or sodium hydroxide will react with the phenol forming sodium phenolates which remain in the caustic solution. This is an immediate reaction after which the solvent is returned to the extractor for reuse. On waste that may contain some hydrogen sulfide, it may be advisable to strip the solvent free of the gas before the scrubbing operation. This would prevent the excess use of caustic due to the formation of sodium sulfide and hydrosulfide. If a condition should arise whereby the caustic was being consumed by hydrogen sulfide, a liberation of the phenols would occur. The phenols would then be redissolved in the solvent and returned to the extraction operation, causing a decrease and possibly a nil effectiveness in the extraction of phenolic material from the waste.

TABLE 3

	Percent Phenol Removal with Stages Numbering					
	1	3	5	7	9	11
100% Aromatics:						
2/5 ratio	35.5	69.0	85.9			
1/1 ratio	73.1	95.2	99.9			
75% Aromatics:						
1/1 ratio	68.3	94.0	98.9			
49% Aromatics:						
1/1 ratio	52.6	88.5	91.6			94.5
35% Aromatics:						
1/1 ratio	41.9	59.2	68.5	72.9	74.8	75.8
3/1 ratio	62.1	81.2	91.1	94.0	94.4	94.5
25% Aromatics:						
1/1 ratio	24.9	41.1	48.7	53.4	55.5	56.4
3/1 ratio	55.6	78.6	83.3	84.1	84.4	84.6
5/1 ratio	68.2	85.1	90.4	90.9	91.8	92.4

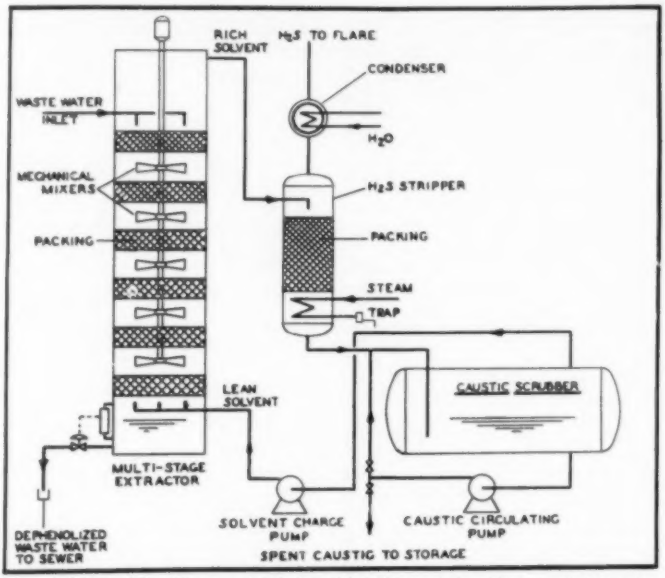


Figure 4. A Typical Flow Diagram of an Industrial Installation of Phenol Reduction by Extraction.

Solvent Loss

The solvent losses would be determined by the solvent type and the process flow-rates. The solvent type governs the loss through solubility in the waste water. The more paraffinic the solvent, the lower the solubility in the water. The presence of inorganic salts would further reduce the solvent loss through solubility. The flow-rates control would govern the amount of carry-over of solvent by waste or the waste by the solvent. The more rapid the flow-rates the more chance for solvent loss. This factor depends upon the design of the solvent extractor.

This study of multi-stage countercurrent extraction operation indicates a possible reduction of 99.9 percent on accumulator wastes originally containing 200 ppm of phenols. The operation would require a five stage extraction column plus a mixed solvent consisting of 66 percent benzol and 34 percent fluid catalytic cracked gasoline used at a ratio of two parts solvent to one part waste water.

The phenol bearing waste enters near the top of the extraction column and passes downward through the five mixing and settling zones contacting solvent containing lesser amounts of phenolic material at each stage. The dephenolized waste, taken from the bottom of the extrctor, is permitted to enter the plant sewer system.

The solvent on the other hand enters above the dephenolized waste exit and passes upward through the extractor contacting waste containing greater amounts of phenol at each stage. The spent solvent is removed from the top of the column and passes through a hydrogen sulfide stripper equipped with a steam heater and water condenser. From the stripper, the solvent enters a caustic scrubber to be freed of dissolved phenol. The regenerated solvent is then returned to the extraction column for recirculation.

A typical flow-diagram of an industrial installation of phenol reduction by extraction is shown in Figure 4. Since the flow of waste and solvent is continuous and adjustable, the equipment may be adapted to various rates and ratios.

The solvent regeneration operation makes it necessary to have a method for the disposal of spent caustic. The amounts of caustic consumed depends upon the phenol concentration in the waste, amounts of waste and the percentage removals. This spent caustic consists of high grade sodium phenolates which have a market value to various chemical companies for the phenol content. These companies usually spring the phenols by the acidification of the spent caustic with acids, acid salts, carbon dioxide or hydrogen sulfide.

Drum Handling Problems Solved With New Layout

Here is complete plan, generously illustrated, showing the modern solution for this technique, so frequently troublesome

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PRACTICAL, profitable, and simple is the drum-handling system at Esso Standard Oil Company, Bayonne, N. J. And the techniques employed there can be applied equally well in other plants—be they large or small, or be they operation receiving, storage, filling, or shipping.

Because Esso Standard must continually meet the rising oil requirements of industry and the general public, its engineers are constantly improving drum-handling facilities to handle more drums faster. The Bayonne plant's handling system has, in fact, grown from the time when drums were manually down-ended one at a time and rolled on their sides, to the present system which, by push button control, speeds drums on end through stenciling, filling and shipping at a rate of eight per minute.

The present conveyor system for mechanically moving oil drums, takes in three floors of an empty-drum storage building, two floors of a stenciling and full-drum storage building, one floor of a drum filling building, plus interconnecting conveyors servicing railroad, truck, and steamship receiving and shipping platforms.

Empty-Drum Receiving & Storage

The three-story empty-drum storage building, Figure 1, is equipped at one end to receive empty drums from freight cars. At the other end, drums are received from trucks.

A slat conveyor, Figure 2, runs the full length of the railroad receiving platforms and connects with other slat conveyors leading to adjacent buildings. An unusual vertical lift bridge, Figure 3, elevates an inter-building connecting conveyor-link when not in use to permit trucks to operate between buildings without interference from the conveyor.

The slat-type conveyor comprises short channel sections secured at each end to motor-driven roller chains installed below the surface of the plat-

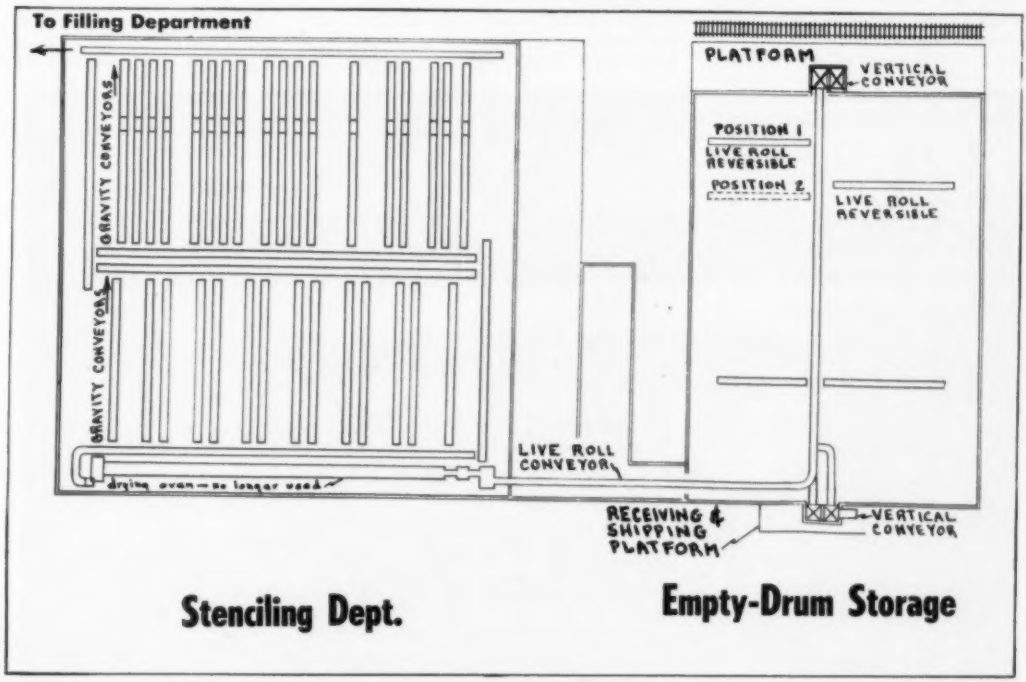

Figure 1. Empty drum storage and stenciling building. This plan view shows the conveyor routing for two of the important operations.

form. The flat sides of the channels are flush with the receiving platform. This type of construction is used here to permit hand trucks used to unload freight cars to roll onto the conveyor.

The slat conveyor delivers drums to a live-roll conveyor which takes them into the first floor of the empty-drum storage building. The slat conveyor is serviced by a vertical lift for second and third floor storage. The truck unloading platform at the other end of the building is also serviced by a vertical lift.

The first floor of this building is divided lengthwise by a live-roll conveyor which extends from the slat conveyor at one end of the building to the truck platform at the other end. At right angles to this main conveyor, on each side, are shorter live-roll conveyors which convey drums to various storage bays. The main conveyor and all the lateral live-roll conveyors are reversible; that is, they can be run in either direction so the system can be used equally well for conveying drums both to and from storage. Portable deflectors are used to divert drums from the main line to the correct feeder lines, and vice versa, as desired. These deflectors are fabricated from aluminum to permit them to be lifted easily and positioned across conveyor intersections to guide the flow according to whether drums are being taken from truck or freight car and delivered to or from storage. Each deflector comprises two curved channel sections, back to back, which sandwich "skate wheels" between their flat sides. An inclined belt conveyor ties in with the above system to transport drums from the first floor of the empty drums storage building to the stenciling department on the second floor of the adjacent building.

Figure 2. A slant conveyor is used to transfer drums from the railroad receiving platform.

The second and third floors of the drum-storage building are similar in layout to the first, being divided lengthwise by a live-roll conveyor connecting the vertical lifts at each end of the building and having feeder lines to and from storage bays. These floors are connected with the stenciling de-

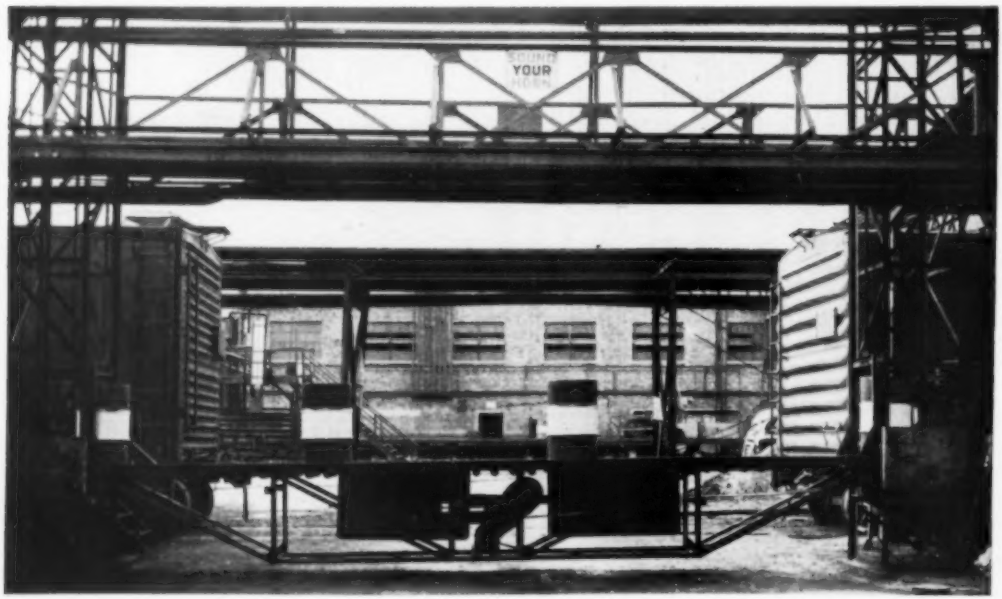

Figure 3. An unusual vertical lift bridge can be elevated to permit truck traffic between buildings.

Figure 4. Drum Filling Section.

Figure 5. Drum Weighing Station.

partment in the adjacent building by a live-roll conveyor.

Drum Stenciling Department

When drums arrive in the stenciling department, Figure 1, they remain on the conveyors for stenciling, eliminating all manual handling operations. This department has two center conveyors, two parallel side conveyors and a series of interconnecting conveyors. Platforms are provided alongside the connecting lines at convenient height for stenciling. The connecting conveyors are of the roller gravity type so engineered that an operator with practically no effort can push a whole line of stenciled drums to live-roll conveyors leading to the filling department.

Drum Filling

From the stenciling department, drums are conveyed to the filling department on the main floor of a third building. Here, drums are filled for shipment by barge, rail, or truck, Figure 4. These drums are checked for weight, Figure 5, and carried by roller-flight conveyor direct to shipping platforms or temporary storage.

The roller flight conveyors move drums at twice the driven speed of the conveyor. The conveyor comprises live rolls, interspersed with step plates, which are moved along by roller chain as they also rotate about their axes. Speed of the drums is that of the chain plus the peripheral speed of the rollers. The step plates between the rollers are a safety measure and preclude accidents should an employee step upon the conveyor in motion.

An electrically-operated deflector, Figure 6, actuated by an operator according to drum stencil-markings, routes filled drums to storage or to any one of two shipping platforms.

Full-Drum Storage and Shipping

Full-drum storage, Figure 8, is the latest phase of the drum handling system to be modernized. The storage floor (the first floor of the drum-stenciling building) has been completely conveyorized to eliminate all manual handling of filled drums. Conveyors completely circumscribe the inside perimeter of the building and two additional main conveyors, perpendicular to rail and truck-loading facilities which flank the building, divide the room into three equal parts. One hundred and thirty-eight cross conveyors connect these two main lines

with one another and with parallel side-wall conveyors. The 138 cross conveyors feed into the two main conveyors and into the outer perimeter lines. Some 2000 to 2500 drums can be stored on these 138 lines. Each line is reversible and the perimeter lines are built in reversible sections so that an innumerable number of independent drum routing possibilities are available and several different loading operations can be carried on at one time. Time needed to remove a drum from storage, regardless of where it is located, is less than 90 seconds. Drums usually flow from storage at a rate of one every ten seconds. Push-button controls located near each conveyor or conveyor section govern the direction of flow.

The conveyors adjacent and parallel to the shipping platforms feed drums into freight cars or trucks by gravity sections extending into the carrier bodies. An ingenious device is used to deflect drums at conveyor transfer points. The device, Figure 7, comprises merely a section of roller chain secured at each end to a rod. By inserting the rods in holes provided at conveyor corners, the chain is stretched across the conveyor to deflect drums as desired. A spring is used at one end of the chain to absorb shock. With this simple device ten different routing possibilities exist at each conveyor intersection.

The complete storage network is elevated to shipping-platform height, thus eliminating lifting and inclines and generally facilitating handling of the heavy drums.

Figure 6. An electrically operated deflector routes filled drums to proper destination.

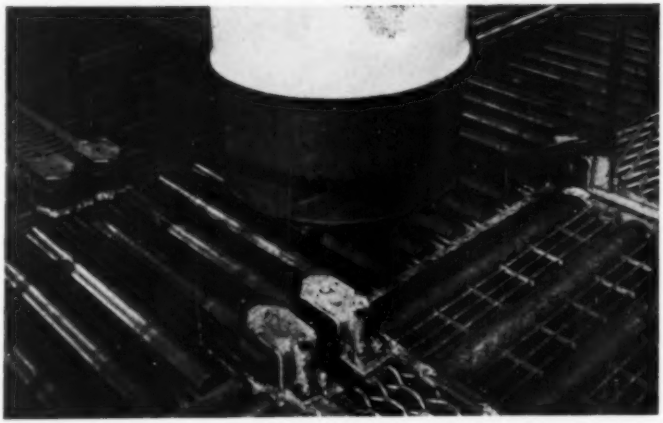

Figure 7. An ingenious device is used to deflect drums at conveyor transfer points.

Figure 8. Full Drum Storage.

Applied Distillation

Part I. Fundamentals

K. E. COULTER

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DURING THE years the author has been in industry, he has met a number of men who have a desire to familiarize themselves with distillation. The first impulse for men in technical brackets is to turn to the literature, but unless they spend a considerable amount of time, absorbing theory and repetitions of theory, their efforts may be fruitless. In the case of technicians, foremen and operators, their efforts are usually confined to asking questions. Since the distillation literature is more than 25 years old, it is difficult for new men to familiarize themselves with the subject and since little has been devoted to actual practice, their questions may go unanswered.

With the above in mind, the author has prepared a series of four articles which are intended to give the reader the high points of distillation. The articles are confined as much as possible to the practical aspects. Literature references are given for those who wish to familiarize themselves with the theory or study the subject more. Whenever possible, examples are given from actual plant operations so as to make the material more understandable.

This article, devoted to distillation fundamentals, begins a four-part series on applied distillation.

MEN operating stills often learn the best conditions to use, but may not understand why certain changes occur. This article will mention fundamentals which should be understood for smooth operation. The more basic are:

1) Why components separate
2) Limiting conditions of reflux ratio and theoretical plates.
3) Effect of reflux ratio on theoretical plates
4) Effect of feed composition on reflux ratio
5) Effect of difference in boiling point on ease of separation and reflux ratio

Distillation makes use of the fact that when compounds are heated and vaporized the vapor leaving is more concentrated in one component than the liquid mixture from which it escaped. In simple distillation work it is assumed if materials have a difference in boiling point they can be separated or concentrated.

The reason is, if a liquid mixture of components *A* and *B*, containing X_0 percent of *A* (Figure 1), is heated to boiling and equilibrium with its vapor is attained, a vapor mixture of component *A* and *B* containing y_0 percent of *A* may result, more concentrated in *A* than the original mixture. Component *A* is assumed to have a lower boiling point or be more volatile than *B* component. Repeating with mixtures containing X_1, X_2, X_3 mole percent *A* vapor mixtures of composition Y_1, Y_2, Y_3 mole percent *A* may result and a curve covering the concentration range from 0 to 100 percent *A* in liquid and vapor may be drawn. The finished curve is the liquid-vapor equilibrium curve for the system composed of components *A* and *B*.

Procedures for determining liquid-vapor equilibrium curves and equipment used have been described by many investigators; a few are Othmer,[5, 6] Coulter, Lindsay and Baker,[3] and Colburn.[2] Liquid-vapor equilibrium diagrams are the basis for distillation calculations.

In simple distillation, the shape of the liquid-vapor equilibrium curves are usually affected by differences in boiling points of components *A* and *B*. Figure 2 is a typical diagram showing effect of boiling point differences. If no difference occurs, the liquid-vapor equilibrium curve will be a straight line with a slope of 45° showing liquid and vapor are the same composition, but if a difference exists the curve will be above the 45° line showing the vapor is more concentrated in component *A* than the liquid. In industry simple distillations are made with varying differences in boiling point, the lowest being about 5° C. Any upper limit may exist.

Figure 1.

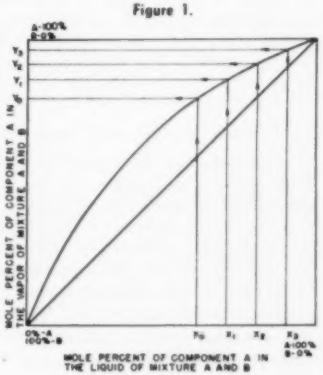
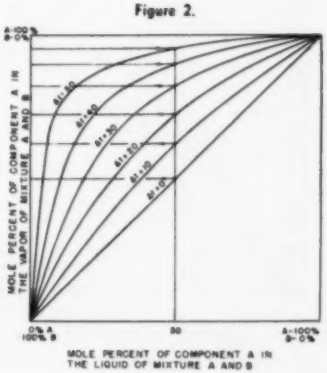

A-100%
B-0%
MOLE PERCENT OF COMPONENT A IN THE VAPOR OF MIXTURE A AND B
0% A
100% B
A-100%
B-0%
MOLE PERCENT OF COMPONENT A IN THE LIQUID OF MIXTURE A AND B

Figure 2.



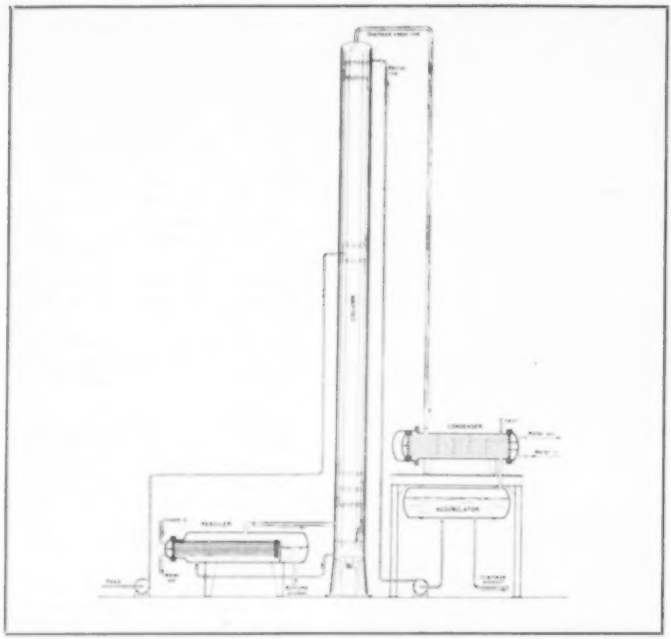


Figure 3. Typical Industrial Continuous Still.

Liquid-vapor equilibrium curves may be used to explain effect of reflux and number of theoretical plates needed in a continuous distillation column of the type shown in Figure 3. For example, if the 20° C. boiling point difference liquid-vapor equilibrium curve of Figure 2 is used in Figure 4 and a feed composition X_F, desired distillate composition X_D, and desired residue composition X_W are plotted thereon, one may show effect of reflux and need for certain theoretical plates. Throughout this paper reference will be made to a theoretical plate, whereas the more correct but less commonly used term theoretical contact should be used. If we assume the feed is liquid at its boiling point, under column operating conditions, we may construct a vertical line through X_F until it intersects the liquid-vapor equilibrium curve at point C and proceed to draw operating lines on a McCabe-Thiele diagram.[4] A McCabe-Thiele diagram uses an upper and lower operating line, the upper operating line being derived from material balance conditions existing in the column above the feed plate and the lower operating line from material balance conditions existing below the feed plate. One upper operating line can be constructed by passing a straight line through X_D and point *C* of Figure 4 to the point of intersection with the *Y* axis. The lower operating line for this case passes through X_W and point *C*. The intercept of the upper operating line and the *Y* axis has the coordinates of $X = 0$ and $Y = \frac{X_D}{R+1}$ where *R* is the reflux ratio and may be defined as the amount of material returned as liquid to the top of the column divided by the amount removed as product per hour. The above operating lines intersect the vertical line through X_F on the equilibrium curve and represent column operating conditions of minimum reflux. The reason minimum reflux conditions exist may be explained by referring to Figure 4 where the needed theoretical plates may be counted by starting at X_D on the 45° line and passing a horizontal line from X_D to the left until it intersects the liquid-vapor equilibrium curve, then a vertical line through this intersection to the operating line, and then horizontally to the liquid-vapor equilibrium diagram until composition X_W is reached. In the case used, with operating lines passing through *C*, the reader will note an infinite number of plates are needed near the feed point, the reason being the lines are nearing an intersection with the liquid-vapor equilibrium curve.

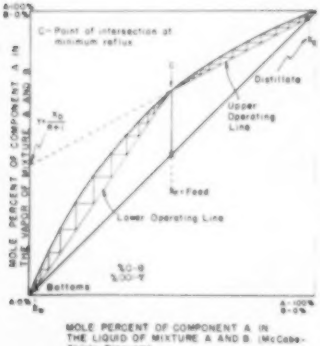

C= Point of intersection at minimum reflux
Distillate
Upper Operating Line
Feed
Lower Operating Line
Bottoms
MOLE PERCENT OF COMPONENT A IN THE VAPOR OF MIXTURE A AND B
MOLE PERCENT OF COMPONENT A IN THE LIQUID OF MIXTURE A AND B (McCabe-Thiele Diagram)

Figure 4.

If, instead of operating with the operating lines intersecting on the liquid-vapor equilibrium curve, the column were operated so the intersection was between the curve and the 45° line, a finite number of theoretical plates could be used. For example, if in Figure 5 the lines intersected at Point *D* the theoretical plates could be counted (solid line) between X_D and X_W and 14 would be needed, whereas if the lines intersected at *E*, 10 would be needed. The reflux Ratio *R*, obtained from the relationship $Y = \frac{X_D}{R+1}$ would be greater at *E* than at *D* and four less theoretical plates are needed. If reflux ratio were increased indefinitely, no product would be removed and the operating lines would coincide with the 45° line. When the operating lines coincide with the 45° line, the column is operating at total reflux representing one extreme in column operation, total reflux $\left(\frac{X_D}{R+1} = 0 \text{ and } R = \infty\right)$ and minimum theoretical plates, whereas minimum reflux and infinite trays, Figure 4, is the other extreme. Neither are useful from the practical standpoint. If the relationship between theoretical

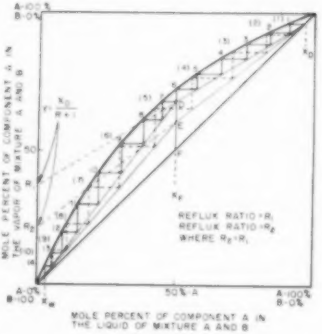


Figure 5.

plates and reflux ratio is plotted between the two extremes, a curve similar to the one in Figure 6 will result.

If the 20° C. liquid-vapor equilibrium curve (Figure 2) is used in Figure 7 and feed composition of X_{f_1} and X_{f_2} plotted, it can be seen that the necessary reflux ratio (minimum or operating) is considerably higher with X_{f_1} than X_{f_2}. From this, it can be said the lower the concentration of low boiling component in the feed, the higher the reflux ratio. The number of theoretical plates may or may not be greater, depending on the feed composition and the shape of the equilibrium curve.

Through out this article and the articles to follow, the author will continually stress liquid-vapor equilibrium curves, McCabe-Thiele diagrams, concentration and temperature gradient curves, because he feels men not equipped with theoretical tools to fully understand calculation methods can successfully and intelligently operate distillation equipment if they understand what is happening.

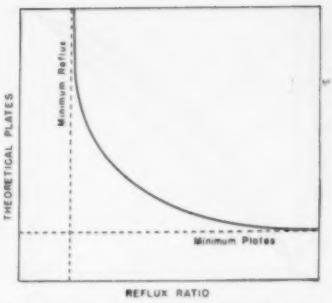


Figure 6. Reflux Ratio Versus Theoretical Plate Relationship.

NOMENCLATURE

A = component with lowest boiling point
Act. = Actual
B = component with boiling point higher than A
B.P. = boiling point
C = A variable constant in the Souders and Brown equation or a component in a mixture
Cst = Centistoke
d_v = Vapor density in lbs. per cubic foot
d_l = liquid density in lbs. per cubic foot
D = distillate rate lbs. per hour
Eqn. or Eq. = equation
GPM = gals. per minute
G or W = mass vapor velocity in lbs. per sq. ft. of column cross-sectional area per hour
H = liquid height in the downcomers
HETP = height of packing equivalent to a theoretical plate
L_M = lbs. per hour of liquid passing through the stripping section of the column
L_N = lbs. per hour of liquid passing through the rectifying section of the column
L_V = latent heat of vaporization in British thermal units per lb.
ΔP = pressure drop in inches of water per foot of packing
PPM = parts per million
W or G = mass vapor velocity in lbs. per sq. ft. of column cross-sectional area per hour
Weq. or Geq. = allowable mass vapor velocity in lbs. per sq. ft. of column cross-sectional area per hour calculated from the Souders and Brown equation.
X = mole % of component *A* in the liquid
Xc and Xp = compositions at the extremities of a theoretical plate
X_n, X_1, etc. = various concentrations
X_F = mole % of component *A* in the feed
X_D = mole % of component *A* in the distillate
X_W = mole % of component *A* in the residue
X_{still} = mole % of component *A* in the pot of a batch still
R or RR = L/D = reflux ratio
Rectifying Section = the section of column above the feed plate
Sp. Ht. = Specific heat in British thermal units per lb. per degree Fahrenheit
Stripping Section = the section of column below the feed plate
T = temperature
ΔT = temperature difference °C.
V_N = lbs. per hour of vapor passing through the rectifying section of the column
V_M = lbs. per hour of vapor passing through the stripping section of the column
y = mole % of component *A* in the vapor
$\phi = \sqrt{\frac{d_v}{0.075}}$ where 0.075 is air density in lbs. per cubic ft.
∞ = infinity
μ = viscosity
$\nearrow\!\!\!\!\rightarrow$ = adjustable line

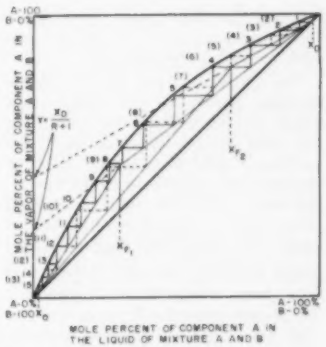


Figure 7.

Continuous Distillation of Binary Mixtures

Continuous distillation is an important operation in the organic chemical and petroleum industry. Stills are in use where feed is fed into the column and one product or mixture of products is taken from the top as distillate and another product or mixture of products is removed from the bottom as residue. Figure 3 is a diagram of a continuous still.

An important problem in continuous distillation is location of the proper feed point. This problem can be solved and explained by referring to the liquid-vapor equilibrium curve and the McCabe-Thiele diagram Figure 8. If a feed composed of X_F mole percent *A*, in a mixture of *A* and *B*, is fed to a column the composition on the feed plate should be between X_C and X_P for proper operation at the reflux ratio shown. Any other feed plate location represents a waste of equipment and in some cases may falsely convince the operator his equipment is undersize. In actual operation it is difficult to know where X_C and X_P are, but the operator should concern himself with

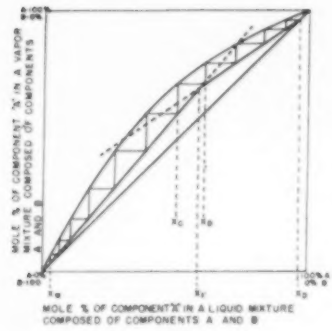
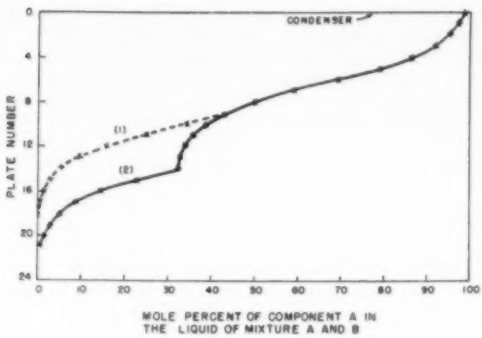

MOLE % OF COMPONENT 'A' IN A VAPOR MIXTURE COMPOSED OF COMPONENTS A AND B
MOLE % OF COMPONENT 'A' IN A LIQUID MIXTURE COMPOSED OF COMPONENTS A AND B

Figure 8.

Figure 10.



locating the feed point on a plate where composition is as near as possible to feed composition.

The conventional McCabe-Thiele diagram points to the composition which *should* exist at the feed plate but other compositions *may* exist. Regardless of feed plate composition one changes from upper to lower operating lines at the feed plate. If the feed plate has a concentration lower in component *A* than the feed, the upper operating line is followed to the actual feed plate composition (Figure 9). Twenty-one theoretical plates are used with fed introduced too low whereas, 19 are needed when feed is introduced at the correct plate. If compositions, shown in Figure 9, are plotted in Figure 10, as concentration vs. plate number, one can readily see the center of the column is inactive. Since a large number of plant columns operate at efficiencies below 100 percent the operator may be wasting more than the theoretical plates shown on the diagram.

If, instead of adding feed containing 50 percent *A* at a feed plate having a composition of 38 percent *A*, (Figure 9) it were added on a plate of composition 55 percent *A*, a diagram similar to Figure 11 would result and the concentration versus plate number curve would show a waste of plates.

It should be noted with a misplaced feed plate the operator cannot tell when the feed is too high or too low in the column by taking samples of distillate and bottoms product. The above statement is confusing and misunderstood by many operating men, but can be explained by discussion of Figures 9, 10 and 11. Assume a 17 theoretical plate column in operation with feed too low in the column but with operating conditions such that a distillate of composition X_D was being obtained. Under these conditions (Figure 9) the residue would contain 12.3 percent *A* whereas 6.8 percent *A* should be in the residue. Now assume the came column with a distillate composition of X_D but with feed too high in the column (Figure 11); this condition would give a residue containing 12.3 percent *A*. This shows that a feed too high or too low can give residue containing too much component *A*. The reverse can be shown if good residue but impure distillate is being made.

To further emphasize troubles encountered with misplaced feed points assume feed were too high and residue containing too much component A was produced (Figure 11). If the operator decided to raise the feed plate three more theoretical trays (actual operation may be from 3 to 12), three trays would be wasted and a residue containing 30.7 percent *A* would be obtained. The same would be true if feed were too low and the feed point were lowered when impure distillate was produced.

It cannot be overemphasized that feed should be introduced at the proper plate in the column and sufficient sample points should be installed so concentration gradients in the column can be followed. In cases where wide differences in boiling point occur, the same results, as obtained by concentration gradients, may be obtained by temperature gradients through the column.

A typical example of trouble encountered in the plant is given in Figure 12. As shown feed containing 60 percent *B* is entering plate No. 33 where the concentration is 35 percent *B*. As the result plates 20 to 33 are relatively ineffective and 13 of the 45 plates or 29 percent of the column is wasted.

When temperature gradients are used the author feels at least 15°C. difference in boiling point (at the same pressure) should exist between the two components being separated. Mention is made of the same pressure conditions because in many vacuum distillation columns 40-50° C. difference may exist between top and bottom of the column but temperature change is not sufficient from plate to plate. The 40-50° C. difference is caused almost entirely by pressure drop through the tower which elevates the boiling points. If temperature versus plate curves are plotted they may appear as in Figure 13 for proper feed plate location Curve 1; a feed introduced too high Curve 2; and a feed introduced too low, Curve 3.

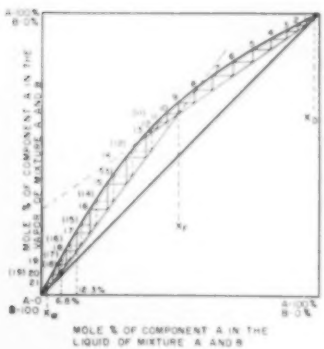


Figure 9.

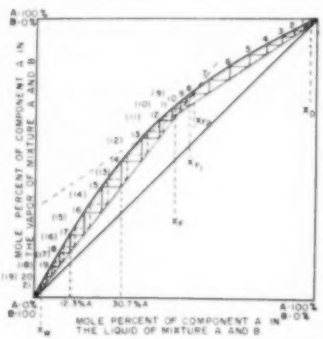


Figure 11.

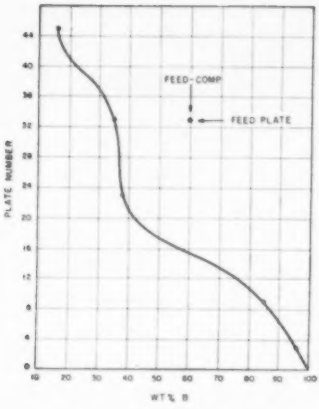


Figure 12. Weight Percent B.

Figure 10 is helpful in explaining where maximum and minimum concentration changes occur in properly fed columns. In Curve 1, concentration changes rapidly from 5-95 percent *A* but slowly from 0-5 percent *A* and 95-100 percent *A*. With the above the operator can understand why it is difficult, in many cases, to remove traces of impurities. Up to the present the author has been concerned with temperature and concentration gradient curves and mislocation of feed points on columns which are just large enough for the job on which they are being used. The next is columns having more than the needed theoretical number of plates when properly operated.

When excess theoretical plates are present the operator may combine column sizes, concentration curves and operating conditions to insure good operation with reasonable safety factor. For example, if design calculations showed 15 theoretical plates were needed and experience or pilot plant data predicted 60 percent tray efficiency 25 trays should be installed and experienced designers would probably install 6 to 10 more to allow for operational irregularities. The column could be operated in three ways and only one would give the available safety factor. This can be explained by Figure 14 where curve 1 shows required distillate purity is obtained and 10 plates are unnecessary at the bottom; Curve 2 where required residue purity is obtained and 10 plates are unnecessary at the top, and Curve 3 where 5 unnecessary plates are present at the top and 5 at the bottom. All properly designed plant distillation columns should have more plates than are actually needed for the job because changes in weather conditions, failure of instruments or other operational upsets can be expected and without a safety factor product specifications cannot be met. When measurements show more plates than needed operating conditions and feed plates should be adjusted so spare plates exist on both ends of the column. In many cases more may be preferred on one end of the column than the other, depending on where the products are used and specifications. A discussion will follow in the article on instrumentation regarding methods of changing the concentration gradients from one section of the column to the other.

Typical plant test data obtained in a commercial benzene-toluene column are shown in Figure 15 so the reader can see the actual values and changes in liquid concentration, vapor concentration and temperature. As shown three excess plates exist on both ends of the column. Figure 16 presents data taken on a commercial ethyl-benzene-styrene column with misplaced feed. Little change in concentration occurs from Plate 8 to Plate 19 and on this particular column 38 plates were installed and 11 were inactive.

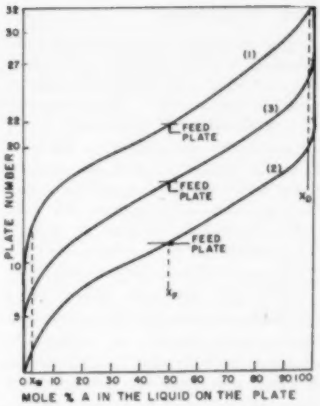


Figure 14. Mole Percent A In The Liquid On The Plate.

A practical procedure to follow in checking column operation would be as follows:

1) Adjust all instruments and valves and operate under steady conditions.

2) Obtain samples of the feed, residue and distillate and analyze.

3) Obtain samples from various plates and analyze for purity or record temperatures in the column.

4) Plot a concentration versus plate number curve and note its shape and feed plate composition.

5) If the curve is not smooth but similar in shape to Figure 12 raise the feed plate, or vice versa.

6) Redetermine concentration or temperature gradient curves and repeat step 5 until the concentration gradient curves are of suitable shape.

7) Obtain necessary repeat checks on concentration gradients and feed compositions to be sure smooth operation is being obtained and instruments are functioning properly.

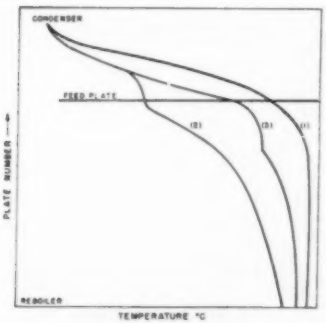


Figure 13. Temperature °C.

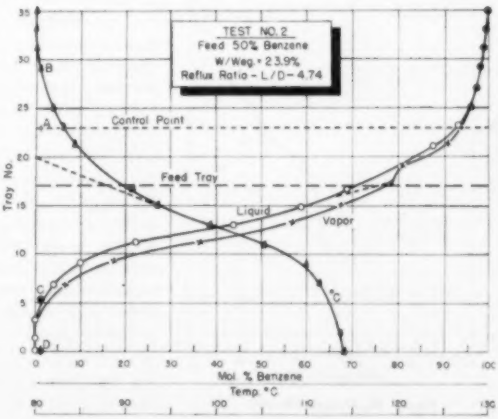


Figure 15.

Batch Distillation

Batch distillation is a familiar unit operation in the chemical and petroleum industry. It is widely used in pilot plants, small manufacturing units, and analytical laboratories.

Batch stills are similar to the unit shown in Figure 17 and are usually piped and controlled much the same. They are simple to operate, few controls are needed and after an operating schedule has been determined they can be operated with little supervision.

Batch still operation differs from continuous because the reflux ratio and heat input should be continually changed while the still is in operation. A batch still handling a mixture of components *A* and *B* gives a fraction or cut containing both *A* and *B*, which must be recycled and reloaded with the next charge. By its nature, the continuous still gives constant output and constant quality whereas the batch still delivers product at a variable rate and approximately constant quality only when in the main fraction. During the period the batch still is loading or unloading no product is made and considerable attention is required. Continous still attention is constant.

Liquid-vapor equilibrium curves used in batch distillation are the same as in continuous distillation, but when the McCabe-Thiele diagram (1, 4) is constructed only the upper operating line exists. The still pot is the feed plate for the only section of the column present, and still pot composition is the composition existing on the feed plate. A McCabe-Thiele diagram (1, 4) for a batch column could be as shown in Figure 18. The upper operating line has been constructed so it intersected the vertical through X still slightly below the liquid-vapor equilibrium curve. If the intersection occurred at the liquid-vapor equilibrium curve an infinite number of theoretical plates would be needed to accomplish the desired separation. This condition, covered previously under minimum reflux ratio, was shown by drawing lines representing theoretical plates between the operating lines and the liquid-vapor equilibrium line. As the intersection was approached an infinite number of theoretical plates were needed.

Figure 19 is an expansion of the diagram shown in Figure 18 and shows pot composition and the reflux ratio changes as the distillation progresses and low boiling component is depleted from the stillpot. It should be noted that all operating lines go through the same distillate composition, this is necessary because specifications on the product usually state a constant composition. The last operating line intersects the vertical thru X_{n-11} just below the liquid-vapor equilibrium line and the number of plates necessary to make the separation under these conditions is the minimum theoretical number which should be installed. It represents the worst conditions. All batch stills should be designed with sufficient plates to make the separation between X_{n-11} and X_D. By designing for these conditions, more plates than necessary will be present during most of the distillation, allowing the column to operate near the minimum reflux ratio until X_{n-11} is reached. If the column is operated or designed to remove all but one to two percent of the more volatile component *A*, there will be little choice as to the number of theoretical plates and reflux ratio, because in this case the equilibrium curve and the 45° line are approaching each other.

After the batch still has been loaded and refluxed until equilibrium is reached a reflux ratio is picked and product of composition X_D is taken forward. Referring to Fig. 19, if the initial still composition is assumed as X_{n-1}, the reflux ratio at the start must be slightly greater than the value calculated by passing a line through X_D

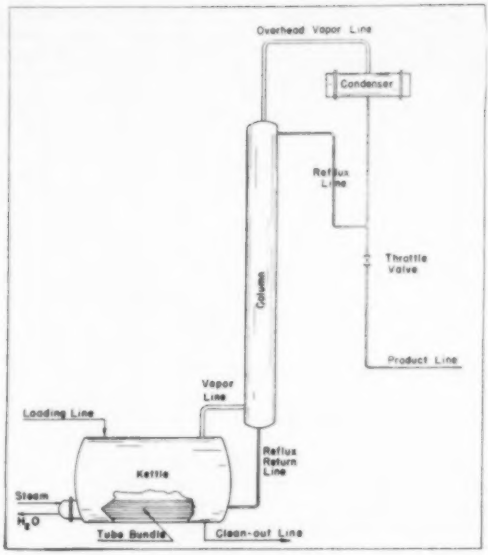


Figure 17. Industrial Batch Still.

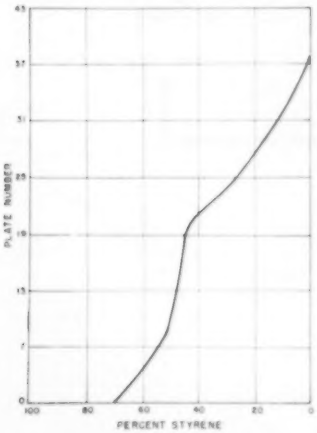


Figure 16. Percent Styrene.

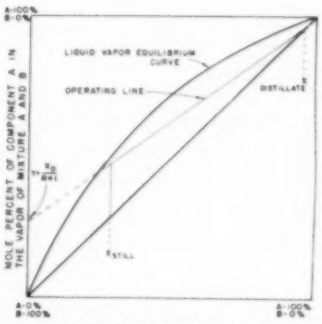

LIQUID VAPOR EQUILIBRIUM CURVE
OPERATING LINE
DISTILLATE
MOLE PERCENT OF COMPONENT A IN THE VAPOR OF MIXTURE A AND B
MOLE PERCENT OF COMPONENT A IN THE LIQUID OF MIXTURE A AND B

Figure 18.

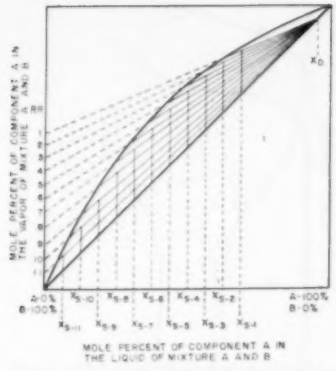


Figure 19. Batch Distillation. Mole Percent Of Component A In The Liquid Mixture A And B.

and the intersection of the vertical through X_{6-3}, and the liquid-vapor equilibrium curve. This value is the lowest reflux ratio that can be used during the distillation and make product of composition X_D. As product is removed the still composition decreases in component *A* and as composition X_{6-2} is reached the reflux ratio must be increased to a value slightly greater than calculated using X_D and X_{6-2}. If this procedure and reflux ratio increases are repeated until X_{6-11} is reached, a curve similar to the one of Figure 20 will result. Figure 20 should be understood for successful operation of batch stills. If distillate composition is to remain constant reflux ratio must be continually increased. The results shown in Figure 20 are values which give the operator maximum production from his equipment, an important factor from the standpoint of cost.

If a mixture, of components *A* and *B* boiling at T_1 and T_2 respectively, is distilled. Curve I Figure 21 may be obtained when suitable equipment is used, and reflux ratio is properly adjusted. If a properly designed column were operated between X_{6-1} and X_{6-4} (Figure 19) at the correct reflux ratios, and after X_{6-4} was reached the reflux ratio was kept constant at that needed at X_{6-4} Curve 2 Figure 21 could be obtained. Obviously, operations of this type would obtain more product per unit of time, but considerable mixed fraction for recycling to the next still load would be obtained.

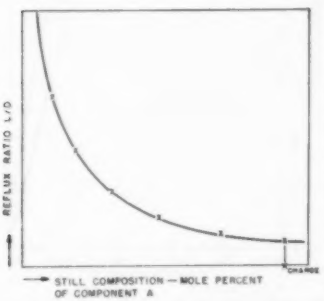


Figure 20.

Operations explained in Figure 21 could be illustrated by plotting recorded temperature values, Figure 22, for the operations where curves 1 and 2 were obtained. Conditions shown in Figure 21, Curve 1, give a sharp temperature break and little mixed fraction, where impure *A* is obtained, whereas conditions for curve 2 give a slower break and considerable mixed fraction.

Curves shown in Figure 22 are typical of batch still temperature recorder records. As shown, the column warms up and the top temperature rises above T_1 the boiling point of *A*, but when reflux is applied the top temperature drops to T_1. After a period at T_1, equilibrium will be reached and the operator can withdraw product. Any material removed before equilibrium is reached is obviously impure.

Figure 23 is a plot of top temperature and still temperature for the conditions of Figure 20. Figure 23 is an excellent guide to the progress of the distillation, and aids in knowing when to increase reflux ratio. The stillpot will show a gradual rise in temperature; will start out between T_1 and T_2 and will be above T_2 when all of *A* is removed. The difference as compared with the overhead temperature may be caused partially by pressure drop thru the column, which elevates the boiling point.

Continuous Distillation of Multicomponent Mixtures

Multicomponent distillation is common in industry. Mixtures containing three components or more are fed into a column and one or more components are taken as residue and one or more as distillate. The same control systems and columns are used as with binary systems. In the oil industry, multi component columns usually remove a number of products as residue and a number as distillate whereas in the chemical industry one product is usually removed as distillate and a number of components as residue. For example, if the components of a natural gas were separated for chemical use, methane would be removed in the first column, ethane in the second, propane in the third, etc. A typical flow-

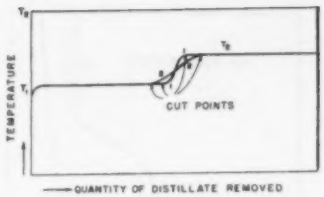


Figure 21.

sheet would be as shown in Figure 24. When all components of a mixture are desired as distillates, the same number of columns as products are needed, but if only a separation is required and color etc. are sacrificed, one less column than the number of products can be used.

Barbet Diagrams—Multicomponent distillation columns give variable Barbet diagrams (plate vs. concentration diagrams), the shape depending on the materials present and their boiling points. For example, a column separating a mixture of 2 percent benzene, (B.P. 80°C.), 2 percent toluene (B.P. 110°C.), 56 percent ethylbenzene (B.P. 136°C.), and styrene (B.P. 145°C.) would have a Barbet diagram similar to Figure 25, when benzene and toluene with traces of ethylbenzene are taken as distillate. Using distillation terminology, toluene would be the light key component and ethylbenzene the heavy key component because they are the compounds between which

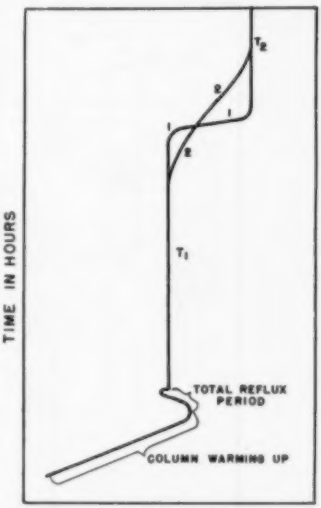


Figure 22.

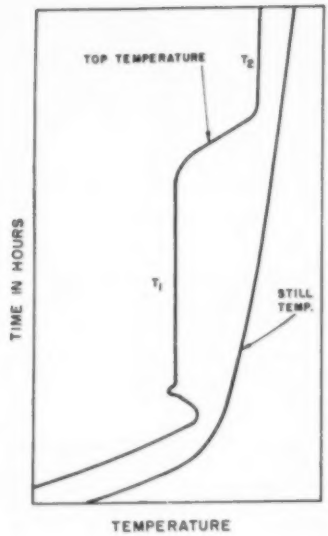


Figure 23.

the cut is made. As noted, Figure 25, the ethylbenzene and styrene concentration are about the same in the residue as in the feed, which is expected, because only 4-5 percent of the feed is removed as distillate. Ethylbenzene and toluene reach maximum concentrations in the tower and gradually decrease. Maximums occur whenever components have a boiling point between the temperatures which exist at the ends of the column. Figure 26 is the temperature gradient curve and since little concentration change exists below the feed plate little temperature change occurs. The change in temperature is caused largely by pressure drop thru the column and not by concentration changes. Benzene boils 30°C. lower than toluene so little appears in the liquid phase in the column until the last plates are reached.

If the distillate from above is fed to another column and benzene is removed as distillate and ethylbenzene and toluene as bottoms product, the concentration diagram Figure 27 could be obtained.

Ethylbenzene boils 26°C. higher than toluene and is found on the bottom plates; it does not reach a maximum because its boiling point is not reached in the column. Benzene reaches a maximum at the top of the column, the temperature corresponding to its boiling point. Toluene reaches a maximum at the point where ethylbenzene is essentially depleted and its boiling point is reached. If no ethylbenzene were present the reboiler would be at the toluene boiling point. The temperature gradient curve is given in Fig. 27.

Figures 25 and 27 are valuable guides when feed contains low or high boiling materials which contaminate the product. In the case of Figure 25, a product could be removed as a sidestream containing little benzene or in Fig. 27 a sidestream could be removed containing little ethylbenzene. Sidestreams are common in the alcohol industry where aldehydes etc. concentrate in the distillate. Essentially aldehyde-free alcohol is removed as a sidestream. With light and heavy components in feed, the greater the difference in boiling point the easier it is to remove sidestreams containing little of the by-products. Barbet diagrams are useful in predicting plates where unsaturated compounds can concentrate and polymerize or where materials with high melting points can concentrate and solidify.

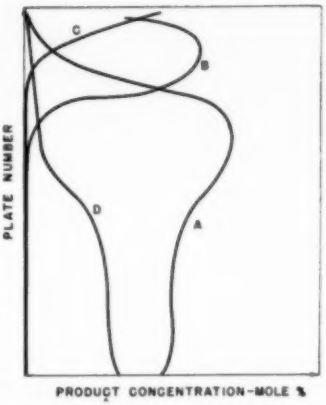


Figure 25. Barbet Diagram For Typical Distillation Column. A—Ethyl Benzene; B—Toluene; C—Benzene; D—Styrene.

In multicomponent distillations partial condensers are commonly used when a number of products are removed as distillate. With partial condensers some components are removed

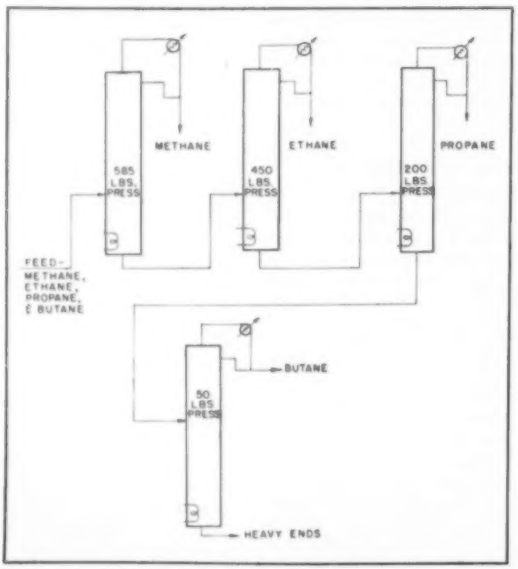


Figure 24. Natural Gas Separation.

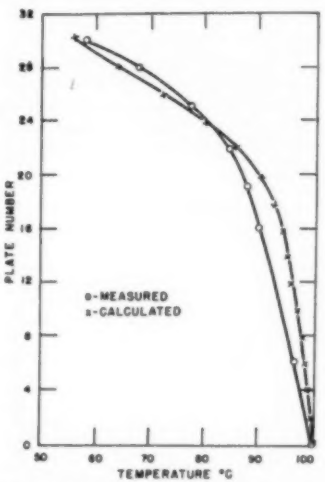


Figure 26. Data For Figures 25 and 26 Are From The Same Column.

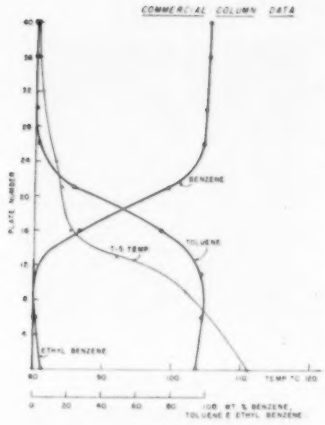


Figure 27.

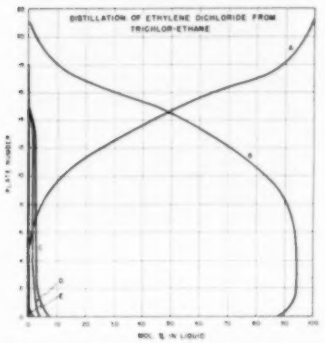


Figure 28. A—Ethylene Dichloride, B—Trichlorethane, C-D-E—Tetra And Penta Chlorethanes.

as gases and some as liquids. Examples are gasoline stabilizers, demethanizers, strippers, etc.

Multicomponent distillations are carried out with a number of columns operating in series. In cases where as high as eight components are separated, the residue from one column may be fed to the following column or the residues may be stored in tanks and fed as desired to the next column. Systems without tanks are more difficult to operate, but are cheaper to install. Large numbers of columns in series mean more equipment to start at one time and more to go out of control when an upset occurs.

In the chemical industry where single components are taken overhead, the separation is much the same as in a binary system. This can be explained by reference to Figures 28 and 29 where the calculated Barbet diagrams for chlorinated ethanes is given. As noted, the top section of the column Figure 28, is concerned with separating ethylene dichloride from trichloroethane and in Figure 29 with the separation of trichloroethane from tetrachlorethane. The above materials have reasonable differences in boiling points and the components boiling higher than the heavy key components appear principally below the feed plate. Many authors have presented calculation procedures which reduce multicomponent to binary systems for greater ease in calculation of reflux ratios and theoretical plates.

In cases where Barbet diagrams similar to Figures 28 and 29 occur, the upper section of the column resolves itself into a binary system and the control system is simplified and essentially the same as in a binary system. With Barbet diagrams similar to Figure 25, where two components are taken as distillate and two as residue, the control system is more complicated if a sharp cut is to be obtained between toluene and ethylbenzene. The control system is complicated because the measurement of one variable does not define the system. In this case, two variables must be measured. Satisfactory control can be obtained by measuring one variable, temperature, on the plate and keeping it high enough so some ethylbenzene is removed as distillate and then two more stills can be used to separate benzene from toluene and toluene from ethylbenzene. With the Barbet diagram, Figure 27, a control point above the feed inlet would be controlling a two component system of benzene and toluene, and the other column, Figure 30, would be separating ethylbenzene and toluene. The residue from the column, Figure 27, is ethylbenzene and toluene but ethylbenzene does not appear above the feed point because of its high boiling point and low concentrations. Figure 30 is a Barbet diagram or concentration versus plate number diagram for

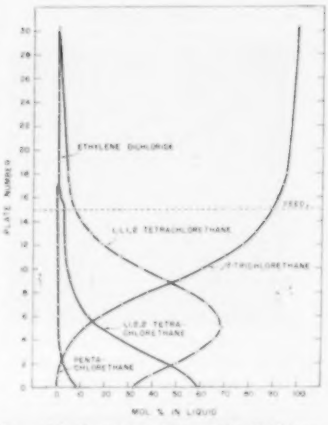


Figure 29. Composition Diagram For Trichlorethane Still.

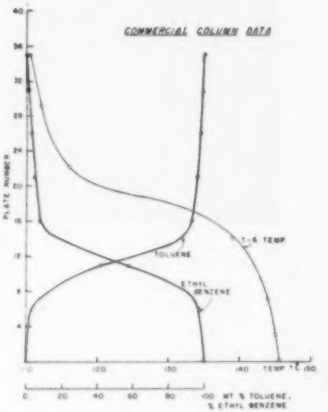


Figure 30.

the column separating toluene and ethylbenzene.

End of Part I. Part II will appear in an early issue.

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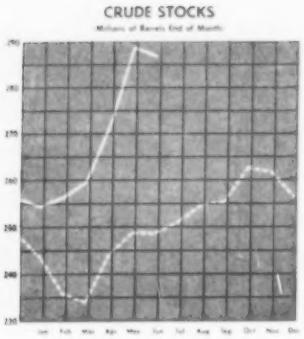

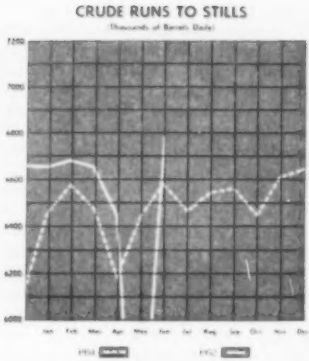

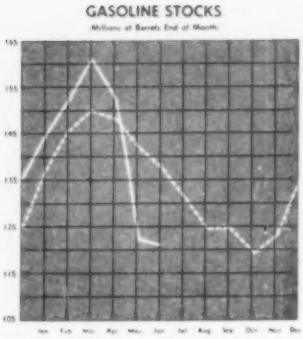

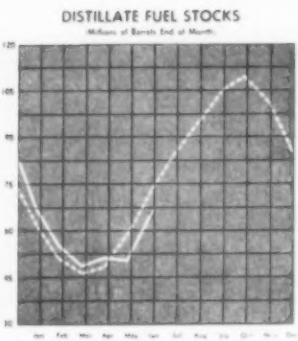

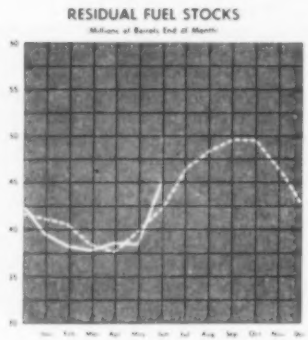

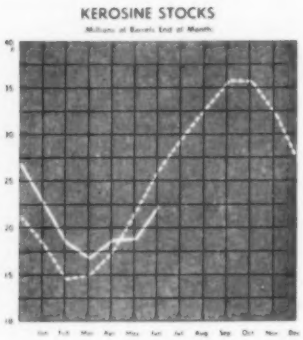

TAKING STOCK

CECIL W. SMITH
Economics Editor

(DATA IN THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1951:													
January	5,907	6,450	243,107	2,962	136,145	410	18,634	1,427	62,163	1,368	41,251	499	977
February	5,930	6,562	235,247	2,906	145,184	410	14,776	1,419	51,348	1,382	40,716	468	937
March	6,052	6,469	233,824	2,908	149,679	399	15,135	1,327	46,744	1,348	38,366	483	861
April	6,127	6,183	243,180	2,821	147,679	384	17,639	1,171	48,239	1,230	37,623	511	871
May	6,170	6,436	248,418	3,031	141,658	345	21,974	1,210	59,272	1,265	39,879	518	876
June	6,130	6,575	248,170	3,100	137,009	317	26,204	1,254	72,140	1,277	42,398	563	876
July	6,141	6,462	250,847	3,091	130,931	341	29,679	1,228	84,282	1,275	46,320	546	788
August	6,232	6,539	254,276	3,114	124,202	339	32,728	1,237	94,028	1,226	48,365	529	780
September	6,261	6,558	254,900	3,127	124,530	364	35,773	1,282	104,082	1,228	49,608	500	744
October	6,375	6,446	262,266	3,105	118,864	363	35,759	1,295	109,544	1,224	49,573	421	769
November	6,272	6,609	261,100	3,130	122,723	403	32,116	1,358	101,666	1,304	46,491	425	802
December	6,182	6,646	255,783	3,170	134,867	393	27,088	1,442	86,619	1,313	42,853	423	834
1952:													
January	6,217	6,640	254,007	3,094	144,339	421	22,679	1,456	66,969	1,338	39,523	488	951
February	6,367	6,673	255,900	3,109	151,912	370	18,530	1,528	55,369	1,322	38,295	491	940
March	6,388	6,640	259,126	3,069	160,689	386	16,817	1,400	48,730	1,274	37,971	510	947
April	6,429	6,435	270,679	2,995	151,890	366	18,955	1,312	51,634	1,253	38,561	539	922
May	5,107	4,935	280,813	2,295	123,656	229	19,614	982	51,648	979	38,821	545	951
June	6,132	6,777	286,291	3,166	120,511	323	22,616	1,394	63,114	1,248	43,314	581	901
June, 1952—Change:													
In Month	+1,025	+1,872	—4,522	—871	—3,145	+94	+3,002	+412	+13,466	+269	+6,493	+36	—50
In Year	+2	+202	+38,121	+66	—16,498	+6	—3,588	+140	—7,026	—29	+2,916	+18	+25
Week Ended:													
7-19-52	6,078	6,919	282,215	3,288	117,380	329	25,128	1,447	77,361	1,254	49,596	502	796
7-21-51	6,166	6,406	249,012	3,052	122,104	354	26,402	1,246	74,606	1,220	44,146	541	758

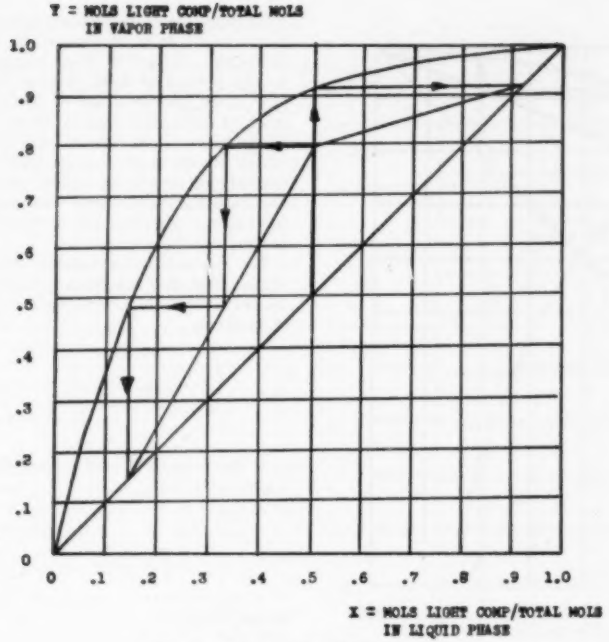

Figure 1. Typical McCabe-Thiele Diagram.

Analytical Solution for Crowded Ends Of McCabe-Thiele Diagram

ROBERT G. BLICK

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IN THOSE cases where binary distillation calculations are encountered in the refining industry, the engineer usually uses the McCabe-Thiele graphical method for determining the number of theoretical plates required to effect the separation.

When the McCabe-Thiele method is applied to precise fractionations, the graphical construction at the ends of the diagram become too crowded to work with. This article presents a simple analytical method for obtaining the number of plates in these crowded regions. No new theories are presented, but formulas of utility are derived and recorded for ready application.

MOST distillation applications in the refining industry involve multi-component mixtures. Nevertheless, binary distillation is encountered with some frequency, and many engineers have developed special techniques for solving problems of binary distillation.

The best known procedure for calculating binary fractionation is of course the graphical method of McCabe and Thiele, as illustrated in Figure 1, and thoroughly covered in all the standard works on chemical engineering. This method is quite convenient in many cases, but difficulties are encountered in problems involving relatively high purities at the top or bottom of the column. In these cases it is difficult to step off the number of plates because the graph becomes too crowded, as shown in Figure 2. Usually the designer will draw several enlarged partial graphs in succession, of the crowded ends of the diagram. However, this becomes quite a nuisance at times.

In order to overcome the difficulties of applying the McCabe-Thiele method to precise separations, it is much easier and generally more accurate to step off only that number of plates that can conveniently be handled by the graph, and determine the balance of the plates required analytically. A convenient procedure will now be developed for handling these analytical computations. No new theories are presented, but it is felt that formulas of utility should be recorded for ready application.

The basic principles of the method are illustrated in Figure 3. Let us say that the last graphical enriching plate conveniently stepped off indicates a liquid composition of X_{0t}. It is desired to have a top purity of X_t. Formula I shows how many more enriching plates are necessary, and IA gives the purity for N more enriching plates.

$$N_e \leq \frac{\text{Log}\left(\frac{1-X_t}{1-X_{0t}}\right)}{\log\left(\frac{m_e^*}{m_e}\right)} \qquad (I)$$

$$\text{or } X_t \geqslant 1-\left(\frac{m_e^*}{m_e}\right)^{N_e}(1-X_{0t}) \quad (IA)$$

In this formula, m_e^* is the slope of a line drawn through the last contact point of the equilibrium curve and the upper right hand corner of the diagram. The term m_e is the slope of the enriching line. This formula always gives results on the safe side, except in the case of a reverse curvature near the top of the equilibrium curve. In that case a tangent can be drawn to represent m_e^*. If a more accurate answer is desired, a more accurate formula is shown following the example in this article. Formula I becomes increasingly more accurate as the top purity increases.

Similarly, suppose the last stripping plate conveniently stepped off indicates a liquid composition of X_{0b}. The desired bottom composition is X_b. Formula II shows how many more stripping plates are necessary, and IIA gives the purity for N more stripping plates.

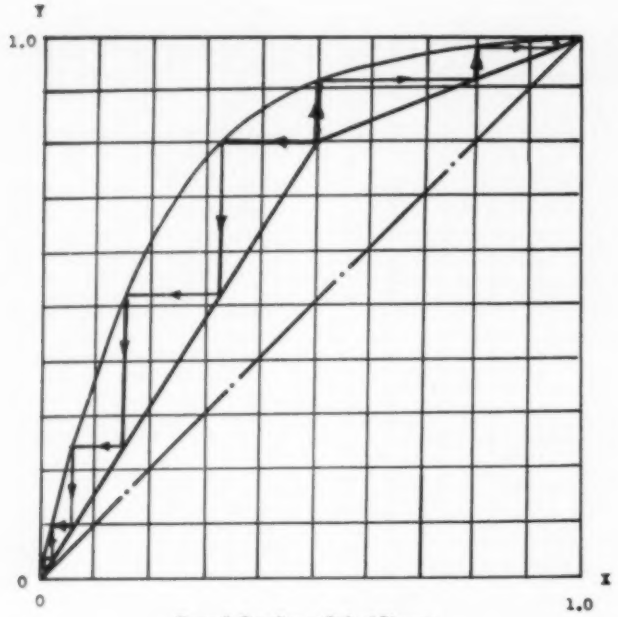


Figure 2. Crowding at Ends of Diagram.

$$N_s \leq \frac{\log\left(\frac{X_b}{X_{ob}}\right)}{\log\left(\frac{m_s}{m_s^*}\right)} \qquad \text{(II)}$$

$$\text{or } X_b \leq X_{ob}\left(\frac{m_s}{m_s^*}\right)^{N_s} \qquad \text{(IIA)}$$

In this formula, M_s^* is the slope of a line drawn through the last contact point on the equilibrium curve and the lower left hand corner of the diagram. The term m_s is the slope of the stripping line. If a more accurate answer is desired, a more accurate formula is shown following the example.

The example uses the equilibrium and operating lines of Figure III. Desired top purity is $X_t = .999$. Desired bottom purity is $X_b = .001$. One enriching plate has been stepped off graphically, and that step ends at $X_{ot} = .800$. Three stripping plates have been stepped off graphically, and the last step ends at $X_{ob} = .060$.

Enriching—The slope of the equilibrium curve in the enriching end is $m_e^* = .125 / 1 = .125$. The slope of the enriching line is $m_e = .400 / 1 = .400$. Working with formula I for the enriching section:

$$\log\frac{1 - X_t}{1 - X_{ot}} = \log\frac{1 - .999}{1 - .800} = \log\frac{.001}{.200} =$$
$$\log .005 = 7.69897 - 10 = -2.30103$$

$$\log\frac{m_e^*}{m_e} = \log\frac{.125}{.400} = \log .3125 =$$
$$9.49415 - 10 = -.50585$$

$$N_e = \frac{-2.30103}{-.50585} = 4.55 \text{ additional enriching plates required}$$

Total enriching plates required = 4.55 plus 1 plate stepped off = 5.55 plates.

By using the more accurate formula in the last section of the article, the additional number required is 3.63 instead of 4.55. Had the top product been specified to a purity of .9999 instead of .999, the balance of plates by the approximate formula comes out to 5.97. By the more accurate formula, the balance of plates would come out to 5.55. In general, the greater the top purity specified, the more accurate the approximate formula is. The answer is always on the safe side, as mentioned before.

Stripping—The slope of the equilibrium curve in the stripping section is $m_s^* = 1 / .250 = 4.00$. The slope of the stripping line is $m_s = 1 / .625 = 1.60$.

Working with formula II for the stripping section:

$$\log\frac{X_b}{X_{ob}} = \log\frac{.001}{.060} = \log .0167 =$$
$$8.22272 - 10 = -1.77728$$

$$\log\frac{m_s}{m_s^*} = \log\frac{1.60}{4.00} = \log .400 =$$
$$9.60206 - 10 = -.39794$$

$$N_s = \frac{-1.77728}{-.39794} = 4.45 \text{ additional stripping plates required}$$

Total stripping plates required = 4.45 plus 3 plates stepped off = 7.45 plates.

By using the more accurate formula in the last section of the article, the additional number of plates required is 3.15 instead of 4.45. Had the bottom purity been specified at .0001 instead of .001, the balance of plates by the approximate formula comes out to 7.0. By the more accurate formula, the balance comes out to 5.62 plates. The formula for the stripping end is more on the safe side, than the formula for the enriching end.

For calculating the balance of enriching and stripping plates more accurately, the following formula is recommended:

$$N = \frac{\log\left(\frac{X_{t \text{ or } b} + \frac{b}{a-1}}{X_{ot \text{ or } ob} + \frac{b}{a-1}}\right)}{\log a} \qquad \text{(III)}$$

If this formula is used for enriching plates, then:

$$a = \frac{m_e^*}{m_e} \text{ and } b = \left(\frac{1 - m_e^*}{m_e} - X_t\,\frac{1 - m_e}{m_e}\right)$$

If this formula is used for stripping plates, then:

$$a = \frac{m_s}{m_s^*} \text{ and } b = X_b\,\frac{1 - m_s}{m_s^*}$$

While the above formula is "accurate," it is only as accurate as the assumption that the equilibrium curve is approximately straight in the region following the last plate graphically stepped off. It gives results very slightly on the safe side. The approximate formulas are useful because of their simplicity. Consequently there is less chance of major errors. Also, in their alternate forms, they are very handy to indicate the relative advantage involved in adding more plates.

Derivation of Formulas

Referring to Figure 4, it is seen that the equilibrium curve is approximated by a straight line through $X = 1$ and $Y = 1$ with slope m^*. The enriching line, likewise is approximated by a straight line through $X = 1$ and $Y = 1$ with slope m. By inspection, it is seen that the number of plates stepped off from these lines will be on the safe side. These lines and the stepping off process are easily represented analytically.

The equation for the equilibrium line is:

$$Y^* = m^* X + c^*$$

To find c^*, solve for Y^* ($= 1$) at $X = 1$

$$1 = m^* + c^*$$

$$\therefore\ c^* = 1 - m^*$$

$$\text{and } Y^* = m^* X + (1 - m^*)$$

$$\text{or } X = \frac{1}{m^*}\,Y^* - \frac{1 - m^*}{m^*} \qquad (1)$$

The equation for the enriching line is:

$Y = m\ X + c$ where c is $(1 - m)$

$Y = m\ X + (1 - m)$

$$\text{or } X = \frac{1}{m}\ Y - \left(\frac{1-m}{m}\right) \qquad (2)$$

Consider the procedure involved in going from a plate just stepped off to the next plate. Say the plate just stepped off ends at $X = X_0$ and $Y = Y_0$. It is desired to find the numerical values of X and Y on the next step from the values at the step just ended.

From Equations (1) and (2):

$Y_1 = m^*\ X_0 + (1 - m^*)$

$Y_1 = m\ X_1 + (1 - m)$

Equating the right sides:

$m^* X_0 + (1 - m^*) = m X_1 + (1 - m)$

From which:

$$X_1 = \frac{m}{m^*}\ X_0 + \frac{m - m^*}{m} \qquad (3)$$

Similarly, using the alternate forms of Equations (1) and (2), it can be determined that:

$$Y_1 = \frac{m^*}{m} Y_0 + \left[1 - m^*\left(1 + \frac{1-m}{m}\right)\right] \qquad (4)$$

The same process is involved in going from plate 1 to plate 2, and from plate 2 to plate 3, etc. As a matter of fact if suitable analytical expressions are available for the operating and equilibrium lines, any kind of lines can be handled in a similar fashion.

Calling $\frac{m^*}{m} = a$ and $\frac{1-m^*}{m} = b$, and using numbered subscripts to indicate the number of the step:

$X_0 = X_0$

$X_1 = aX_0 + b$

$X_2 = aX_1 + b = a^2X_0 + ab + b$

$X_3 = aX_2 + b = a^3X_0 + a^2b + ab + b$

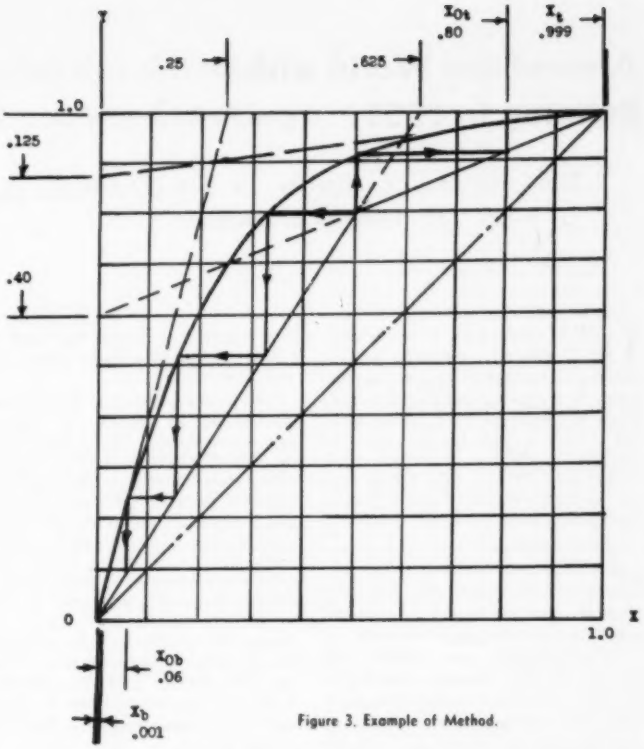


Figure 3. Example of Method.

$X_4 = aX_3 + b = a^4X_0 + a^3b + a^2b + ab + b$

.

.

$X_n = a^nX_0 + a^{n-1}b + a^{n-2}b + \ldots + a^0b$

In the expression for X_n, the terms following a^nX_0 can be written in reverse order to read:

$a^0b + a^1b + a^2b + \ldots + a^{n-1}b$

It is seen that this is the indicated sum of a geometric progression of n terms. Algebraicly the sum is:

$$S = b\frac{a^n - 1}{a - 1}$$

From which it is deduced that:

$$X_n = a^nX_0 + b\frac{a^n - 1}{a - 1}$$

Which is more conveniently written:

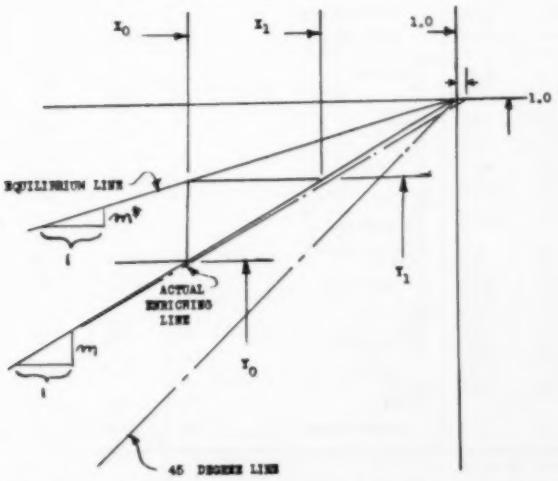
$$X_n = 1 - a^n(1 - X_0) \qquad (5)$$

Equation 5 can be used to estimate the effect of using more plates in a column. Another form of the equation for solving out for a number of plates, given the purities, is:

$$n = \frac{\log\left(\frac{1-X_n}{1-X_0}\right)}{\log\frac{m^*}{m}}$$

In a similar manner the formula for the stripping section can be developed. It is no more difficult to determine more accurate formulas, using the correct equations for the operating lines, rather than the approximate ones that go through $X = 1$ and $Y = 1$ for enriching and $X \& Y = 0$ for stripping. It is on this basis that the more accurate formulas are derived.

Figure 4. Construction for Derivation.



Around the World with Refining in 1951

Daily runs to 722 refineries rise 824,291 barrels. U. S. has 338 refineries in operation

DAILY crude runs to the world's 722 operating refineries in 1951 reached 11,871,099 barrels at the close of the year, up 824,291 barrels from the previous year. These totals are actual, except for estimates required on refinery operations from within the USSR, satellite Europe and various other countries whose politics and government prevented collection of exact figures.

The U. S., continuing as the world's largest refining nation with 338 refineries in operation during the year and daily crude charging capacity of 7,229,000 barrels, was credited with daily crude runs to stills of 6,646,194 barrels, an increase of 502,710 barrels from the previous year. Canada and its burgeoning petroleum industry also reported an increasing trend in refining operations, along with Cuba and Mexico.

Every area except the Middle East chalked up an increase in refining operations during 1951. And there, the Iran-Anglo-Iranian Oil Company controversy resulted in the immobilization of the giant refinery at Abadan and in the sharp curtailment of operations. Consequently, Middle East daily crude runs to stills of its dozen refineries which operated at least a part of 1951 slid from 932,387 barrels in 1950 to 458,097 barrels last year—a decrease of 474,290 barrels. Likewise, Israeli refinery operations fell off during 1951, Border difficulties affecting crude receipts were factors in Israel daily crude runs decreasing 2903 barrels daily.

Refinery expansion in ten Western Europe countries largely offset declines in two others, Belgium, France, Germany, Italy, and Trieste, Norway, Portugal, Spain, Sweden and the United Kingdom together reported an increase in daily crude runs to stills at the close of 1951 of 426,643 barrels from the previous year. Denmark and The Netherlands declined a total of 13,516 barrels for the same period.

Total Eastern Europe refining activities reflected a sizeable increase. This trend amounted to a 103,129-barrel increase in daily crude runs to stills, according to PETROLEUM REFINER sources. In 1950 daily runs totaled 847,032 barrels; in 1951 the figure rose to 950,161 barrels. USSR accounted for more than two-thirds of this spiral, as its daily runs to stills jumped from 729,032 barrels in 1950 to 804,000 barrels in 1951—up 74,968 barrels daily. Other Eastern Europe countries, all within the limits of the Iron Curtain, marked up a 28,161-barrel hike from 118,000 barrels in 1950 to 146,161 barrels at the close of 1951.

The Far East, with 29 refineries and daily crude charging capacity of 327,800 barrels, recorded an increase of 72,291 barrels in daily crude runs to stills. At the close of 1950, the area's daily runs reached 243,290 barrels. At the end of last year, the figure amounted to 315,581 barrels.

World Refining Capacity and Operations

(BARRELS)

CONTINENT and COUNTRY	Number of Plants	Daily Crude Charging Capacity	DAILY CRUDE* RUNS TO STILLS 1951	1950
NORTH AMERICA:				
Canada	45	462,350	343,324	295,032
Cuba	5	6,080	8,355	5,065
Mexico	25	553,780	154,516	142,677
United States	338	7,229,000	6,646,194	6,143,484
Total North America	**413**	**8,251,210**	**7,152,389**	**6,586,258**
SOUTH AMERICA:				
Argentina	23	213,110	135,161	116,129
Bolivia	4	10,391	1,226	1,807
Brazil	5	50,000	2,903	1,613
Chile				
Colombia	2	25,900	24,097	26,516
Ecuador	2	11,800	4,806	4,581
Netherlands West Indies	3	677,000	903,871	831,258
Peru	4	32,300	38,742	36,774
Trinidad	6	123,300	89,290	88,871
Uruguay	1	25,000	16,323	13,419
Venezuela	12	347,370	351,000	311,129
Total South America	**62**	**1,516,171**	**1,567,419**	**1,432,097**
WESTERN EUROPE:				
Belgium	3	37,300	52,710	7,226
Denmark	3	620	387	645
France	14	448,250	419,032	314,517
Germany	39	159,340	94,839	90,323
Italy and Trieste	28	197,600	171,355	126,129
Netherlands	2	124,000	129,097	142,358
Norway	1	1,000	1,032	484
Portugal	1	4,600	8,065	5,323
Spain	1	25,000	9,387	5,581
Sweden	4	24,800	20,968	16,129
United Kingdom	16	539,200	436,612	221,645
Total Western Europe	**112**	**1,561,710**	**1,343,484**	**930,357**

CONTINENT and COUNTRY	Number of Plants	Daily Crude Charging Capacity	DAILY CRUDE* RUNS TO STILLS 1951	1950
EASTERN EUROPE:				
U.S.S.R.	27	1,079,970	804,000	729,032
Other Eastern Europe	59	215,000	146,161	118,000
Total Eastern Europe	**86**	**1,294,970**	**950,161**	**847,032**
Total Europe	**198**	**2,856,680**	**2,293,645**	**1,777,389**
MIDDLE EAST:				
Bahrain Island	1	155,000	209,871	149,774
Iraq	4	16,950	9,677	7,355
Iran	2	552,300	38,710	566,516
Kuwait	1	27,500	26,323	25,710
Lebanon	1	11,000	11,258	11,645
Saudi Arabia	1	160,000	151,290	157,516
Turkey	1	500		
Israel	1	80,000	10,968	13,871
Total Middle East	**12**	**1,003,250**	**458,097**	**932,387**
FAR EAST:				
China	1	17,000	2,258	1,516
India-Burma-Pakistan	3	13,100	10,323	9,355
Japan	19	79,600	73,774	37,935
Netherland East Indies	6	218,100	227,226	194,484
British Borneo				
Total Far East	**29**	**327,800**	**315,581**	**243,290**
AFRICA:				
Canary Islands	1	16,000	16,613	15,710
Egypt	2	47,000	47,613	43,871
French Morocco	1	2,500	2,032	806
Total Africa	**4**	**65,500**	**66,263**	**60,387**
OCEANIA:				
Australia	4	17,500	17,710	15,000
TOTAL WORLD	**722**	**14,038,111**	**11,871,099**	**11,046,508**

* Data from Bureau of Mines "World Petroleum Statistics" for December, 1950 and 1951.

How Charge Stock Properties Affect Carbon Deposition in Catalytic Cracking

Alignment chart yields "coke factor" from four physical properties of the stock

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Magnolia Petroleum Company, Beaumont, Texas

THE quantity of carbonaceous materials deposited on catalyst during catalytic cracking of petroleum hydrocarbons is of importance not only in the design of catalytic regenerators but also influences the scheduling of feed stocks to operating units where regeneration capacity is limited. In the field of catalytic cracking of petroleum fractions data have been published[1] on the effect of operating variables on carbon deposition on catalyst; however, knowledge concerning the effect of charge stock physical properties on carbon formation is limited.

Work was undertaken at the Beaumont laboratories of Magnolia Petroleum Company to determine if the physical properties of various petroleum fractions could be related to their coke forming tendencies during catalytic cracking. The oils investigated included thermal gas oils, catalytic cycle stocks, virgin gas oils and treated stocks.

One sample of visbreaker gas oil was fractionated into cuts in order to produce narrow boiling range fractions of a similar nature and a catalytic cycle stock was solvent treated with various dosages of furfural[2] to produce similar boiling range frac-

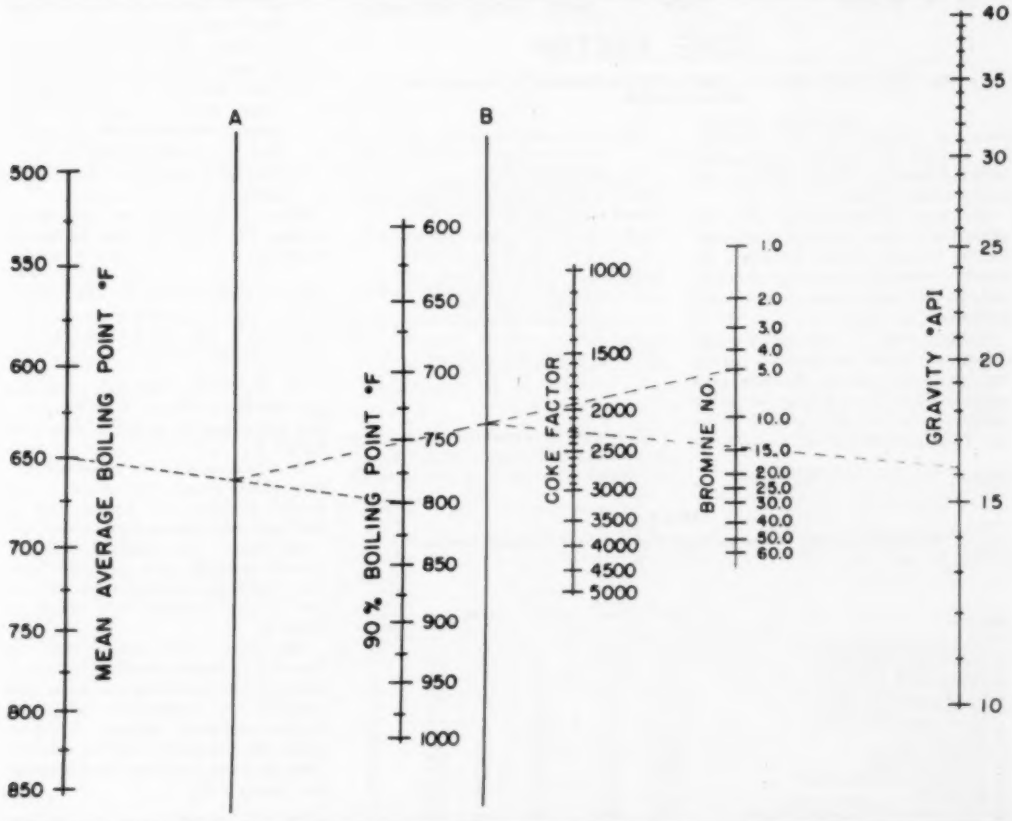


Figure 1. Alignment Chart For Determining Coke Factor From Physical Properties of Charge Stock.

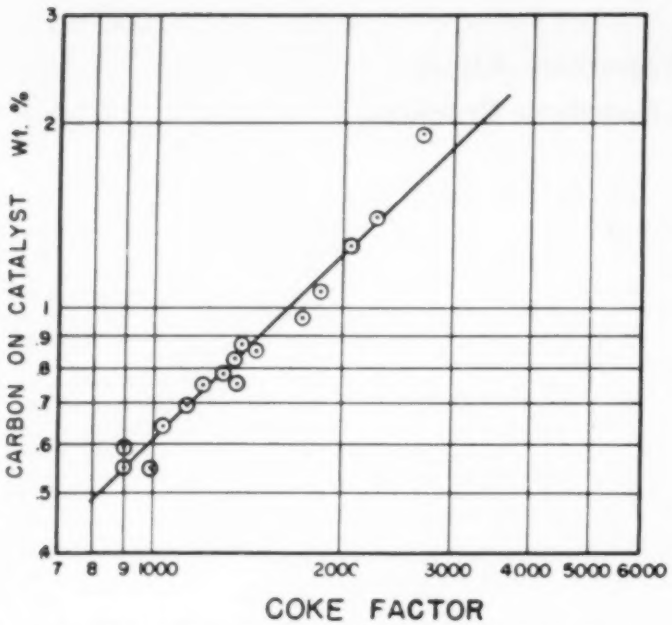


Figure 2. Relation Between Coke Factor and Carbon Deposition for Cracking Over Synthetic Catalyst.

tions but differing in other respects. The catalyst used in the investigation included both synthetic and natural clay cracking catalysts.

The data for correlation were obtained both from fixed bed equipment similar to that used in obtaining the activity index of cracking catalyst[2] and larger scale moving and fixed bed[3] cracking units.

Voorhies[1] shows that for a given charge stock the amount of carbon deposited on cracking catalyst at a given temperature is a function of the residence time of the catalyst in the oil. This is expressed as:

$$\text{Carbon, Wt. \% of Catalyst} = K\theta^n$$

K = A constant depending on charge stock properties and other operating conditions.

n = A constant depending slightly on charge properties and cracking temperature.

θ = Residence time expressed as $\frac{60}{C/O \times S/V}$

C/O = Volumetric ratio of the catalyst contacted per hour by the liquid charged per hour.

S/V = The volume of oil per hour per volume of catalyst in the reactor at any one time.

Herewith is presented work done to evaluate that portion of the *K* factor which is related to the physical properties of a stock.

Correlations were obtained, by the use of simultaneous equations, from the carbon formation of approximately 15 stocks having widely different physical characteristics. All cracking conditions were held constant as follows:

Type of Catalyst	Synthetic
Catalyst Activity Index	30.6
Average Reactor Temp., °F.	850
Space Velocity Vol/Vol/Hr.	1.5
Catalyst to Oil Ratio, Vol/Vol.	4.0

Four physical properties of a stock were found to influence carbon formation. These are:

1) The Mean Average Boiling Point expressed in $°R \times 10^{-2}$. This property can be obtained by any of several methods.[4] If the ASTM 90 percent point of the stock exceeds 600° F. a vacuum distillation converted to atmospheric pressure should be used.[5]
2) The ASTM 90 percent distillation point expressed in $°R \times 10^{-2}$. If this distillation point exceeds 600° F. then a converted vacuum distillation must be used.[5]
3) The Norwood modified bromine number.[6] This property is somewhat difficult to obtain accurately and it is suggested that several determinations be made and the results averaged.
4) The API gravity of the charge stock at 60° F.

These properties are related to carbon deposition in the following manner:

$$\text{Carbon Wt. \% of Catalyst} = K_1 \times \theta^n \times \frac{\left(\frac{\text{MABP}°R}{100}\right)^{4.0} \left(\frac{90\% \text{ Evap. } °R}{100}\right)^{1.6} \text{(Br. No.)}^{.75}}{(\text{API Gr.})^{6.5}}$$

An alignment chart for obtaining the coke factor directly from the physical properties of an oil is shown in Figure 1.

A log-log plot of the observed carbon yield versus the above "coke factor" is shown in Figure 2. This is the basic correlation from which the "coke factor" was obtained and represents cracking over synthetic catalyst. Pertinent physical properties of the stocks studied are shown in Table 1.

Data of a similar nature were obtained for cracking over clay catalyst; however, the operating conditions held constant were modified to correspond to the conditions normally found on units employing pelleted clay catalyst. The operating conditions held constant are shown below:

Type of Catalyst	Clay
Activity Index	30.0
Average Reactor Temp., °F.	930

TABLE 1

Physical Properties of Charge Stocks Cracked Over Synthetic Catalyst

STOCK	API Gr.	Mean Average Boiling Point °F.	90 Percent Boiling Point, °F.	Bromine No.	Coke Factor	Weight Percent Carbon on Catalyst
1. Visbreaker gas oil 0-100 percent	32.9	550	672	21.4	1370	.84
2. Visbreaker gas oil 0-89 percent	33.5	535	661	21.2	1300	.78
3. Visbreaker gas oil 11-100 percent	31.6	572	684	16.7	1430	.86
4. Visbreaker gas oil 11-22 percent	38.5	450	557	29.0	900	.59
5. Visbreaker gas oil 22-78 percent	31.7	560	651	19.4	1390	.76
6. Visbreaker gas oil 78-89 percent	28.5	650	704	12.7	1720	.96
7. Visbreaker gas oil 89-100 percent	27.6	670	724	11.7	1835	1.06
8. Jackson gas oil	31.8	515	666	5.0	1030	.64
9. East Texas gas oil	36.1	540	636	3.0	900	.55
10. Catalytic No. 2 fuel oil	25.6	540	630	17.6	1390	.87
11. Catalytic No. 2 fuel oil	25.2	540	580	3.0	1000	.55
12. Acid Treated Catalytic No. 2 fuel oil	28.0	543	638	8.5	1210	.75
13. Mixed gas oils	27.0	625	832	16.9	2040	1.29
14. Furfural Treated Catalytic No. 2 fuel oil	30.3	550	630	7.2	1140	.69
15. Furfural Extract from Catalytic No. 2 fuel oil	9.8	586	656	24.4	2680	1.93
16. Thermal gas oil	24.7	651	850	15.4	2300	1.39

Space Velocity Vol/Hr/Vol.....1.76
Catalyst to Oil Ratio Vol/Vol.....1.70

A log-log plot of the observed carbon deposition versus the "coke factor" produced a linear relation (Figure 3); however, the slope of the line obtained is greater than the line for synthetic catalysts. This is due in part to the differences in the catalyst and the conditions of cracking. Table 2 gives the pertinent physical properties of the petroleum fractions used in the study of clay catalyst.

In practical application, the "coke factor" (CF) can be used directly in the equation relating operating variables to coke formation[1] as follows:

$$C = K\theta^n$$
$$\text{if } K = CF \times K_1$$
$$\text{then } C = CF \times K_1\theta^n$$
$$\text{if } K_1\theta^n = K_2$$
$$\text{then } C = K_2CF$$
$$\text{or } \log C = \log CF + \log K_2$$

In the log-log plot of carbon deposition versus "coke factor" shown in Figure 2 for synthetic catalyst at the operating conditions used the slope of the line is equal to 1.0 and the above equations are directly applicable in calculating carbon deposition. If, however, the slope of this line is not equal to one as in the case of pelleted clay catalyst the equation changes to:

$$\log C = m \log CF + \log K_2$$
$$\text{or } C = CF^m K_2$$
$$\text{where } m = \text{the slope of the line}$$

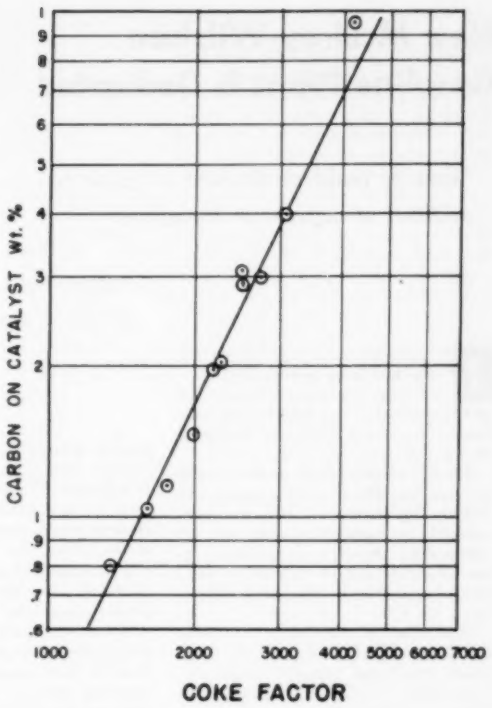
The constant K_2 is a measure of the cracking severity and such other factors as purging efficiency. The evaluation of these factors is outside the scope of this paper.

Limitations to the use of this "coke factor" are as follows:

1) Certain substances poison the various types of catalyst, for example, some sulfur and nitrogen containing compounds.[7] These compounds cause higher carbon deposition than is indicated by the "coke factor."

2) The correlation was established for gas oil cracking and it has been found that low boiling fractions produce more carbon than is predicted from the "coke factor." However, the same physical properties which govern gas oil cracking probably apply to these lighter fractions but to a different degree.

Figure 3. Relation Between Coke Factor and Carbon Deposition for Cracking Over Pelleted Clay Catalyst.



The correlations are based on thorough purging of catalyst after cracking. If purging is done at relatively low temperatures, a heavy residual oil is left on the catalyst. The quantity of this oil can be determined by extraction with benzene. The "coke factor" relates coke on the catalyst exclusive of this extractable oil.

TABLE 2
Physical Properties of Charge Stocks Cracked Over Clay Catalyst

STOCK	API Gr.	Mean Average Boiling Point, °F.	90 Percent Boiling Point, °F.	Bromine No.	Coke Factor	Weight Percent Carbon on Catalyst
1. Catalytic heavy gas oil	18.2	735	786	26.7	3060	3.98
2. Raffinate 25 percent Furfural treated No. 1	22.6	730	809	16.9	2750	2.98
3. Raffinate 50 percent Furfural treated No. 1	27.5	740	798	10.6	2250	2.05
4. Raffinate 100 percent Furfural treated No. 1	30.9	740	796	7.3	2000	1.47
5. Raffinate 200 percent Furfural treated No. 1	34.6	750	800	4.3	1790	1.15
6. Blend 50 percent Catalytic Cycle Stock and 50 percent mixed gas oils	22.1	682	800	20.0	2510	3.10
7. Virgin Mid-Continent gas oil	27.5	570	750	3.6	1330	0.80
8. Miranda crude	23.3	575	775	3.8	1610	1.05
9. Catalytic cracking charge under recycle operation	24.3	645	775	24.6	2200	2.0
10. Thermal Reformer tar	12.3	615	945	59.0	4200	9.6
11. 85 percent overhead No. 10	16.3	540	800	40.9	2500	2.86

* * *

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[6] Herbert L. Johnson and Richard A. Clark, Industrial and Engineering Chemistry, Analytical Edition, Vol. **19**, 1947, Page 869-72.
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New McElroy-Wilshire Gasoline Plant Is Dedicated

Capacity could be doubled in future by addition of compressor horsepower

A Panoramic View of the New Plant near Crane, Texas.

IN ceremonies highlighted by speeches from prominent industry men, the recently completed McElroy-Wilshire gasoline plant near Crane, Texas, was officially dedicated on July 19.

The $1,500,000 plant, owned jointly by Lone Star Producing Company and Wilshire Oil Company, Inc., was constructed by Lone Star and will be operated by that firm. It is located in the Ellenburger-Wilshire oil field which brought in its discovery well on April 15, 1951.

The plant is currently processing 5 million cubic feet of gas daily, well below the design capacity of 16 million cubic feet. Vessels, towers, and structures have been oversized so that the capacity of the plant can be doubled by the addition of compressor horsepower.

Unusual features include the facilities for process water and the availability of underground storage for products. As a part of the special water development project, 18 water wells were drilled in the sandhills northwest of the plant. Installation of 20 miles of pipe to deliver the water to the plant ran the total cost of the water system to $250,000. Water conservation measures include air-cooling systems for exhaust steam, engine water and compressor gas.

The plant's liquefied petroleum products are stored in 14 tanks with a total capacity of 360,000 gallons. A 900-foot salt section underlying the plant area is available for construction of underground storage of the gasoline, propane, and butane. Living quarters have been provided on the 30-acre plant site for the supervisory personnel. An air-conditioned building houses the offices and laboratory.

The raw materials for the plant include separator gas at 50 psi and well gas at 500 psi. The incoming separator gas is compressed to 500 psi and, in admixture with the well gas, is processed through amine and high-pressure absorbers. The gasoline stream is distilled and the overhead product is sent through a series of columns for the removal of ethane, propane, and butane. The residue gas is purchased by El Paso Natural Gas Company, and J. W. Gaddy of Odessa has contracted for the purchase of the liquefied petroleum products. All products are currently transported by tank truck, although a pipe line system is being considered.

Speakers at the dedication included Olin Culberson, chairman of the Texas Railroad Commission, D. A. Hulcy, president of Lone Star, and D. N. McDonnell, vice-president of Wilshire. A. W. Breeland of Lone Star recognized the plant's perfect safety record with the presentation of a special safety award to Joe Francis, Lone Star superintendent.

Left to right: D. N. McDonnell, Wilshire Oil Vice-president, Chairman Olin Culberson, Railroad Commission, and D. A. Hulcy, President of Lone Star.

Lone Star's President Hulcy points out features of the new plant to PETROLEUM REFINER Editor Bob Phillips, center, as J. A. Bates, District Superintendent, looks on.

Thermal Insulation for Industrial Requirements

Part VI—Design Consideration for Low Temperature Range Insulation

In this temperature range the design considerations are discussed with new emphasis on properties other than thermal resistance

RAY THOMAS

Carbide and Carbon Chemicals Company,
South Charleston, W. Va.

THE fundamentals of design and application for elevated and atmospheric temperature ranges have been discussed in previous articles. The primary function of thermal insulation, so far, has been the thermal resistance. Some thought has also been given to other factors affecting heat flow but they have been of somewhat minor importance compared to the major point, thermal conductance. Part VI examines the low temperature or sub-zero temperature range and introduces a new emphasis on some of these properties heretofore mentioned as being of less importance.

Requirements of Installation

Insulated equipment or piping used in sub-zero temperature operation presents the primary problem of moisture control. Moisture, which condenses on the surface of a glass of cold water, condenses in the same manner and for the same reason on the surface of equiment or piping being operated at low temperatures. When the temperature of the metal drops below the dew point of the surrounding air, moisture contained in the air condenses on the cold surface in the form of water which later becomes frost or ice when the temperature has reached 32° F. or below. The mere application of thermal insulation to a cold surface will neither change these conditions nor stop the flow of moisture which would result in condensation taking place.

Water vapor, being a gas, can penetrate any material which can absorb air. When a cold surface on one side of a gas-tight barrier causes the vapor to condense in the form of water, the vapor pressure of the air is reduced at that point. Where a thermal insulating material is applied to this cold surface the inner surface of the insulation subjected to the lower temperature is also in this low vapor pressure area. A pressure difference is therefore created between the warm side and the cold side of the insulation. Since vapor resistance of the thermal insulation is of a low degree generally, a supplementary material called a vapor barrier becomes necessary. The only way to retard the flow of moisture into the insulation is to provide a vapor barrier on the warmer surface.

A "vapor barrier" is so named because its high resistance to the flow of moisture vapor results in slowing down the process of vapor flowing into a thermal insulating material. A vapor barrier does not completely stop the flow of moisture vapor. Since neither a thermal insulating material nor a vapor barrier is entirely effective in stopping moisture-vapor travel, a proper combination should be employed to retard its progress so that the service life of the insulation may be lengthened materially. A rapid rate of vapor migration causes moisture to form within the insulation, resulting in an early failure of the insulation. A poorly designed or poorly applied low temperature installation may fail within a few months whereas a job properly designed and applied will last many years.

It is possible to use metals (and perhaps some plastics which have an extremely small vapor migration rate) and by welding, hermetically seal the insulation to obtain an installation which is practically vaporproof. The extreme difficulty of physically obtaining such a hermetically sealed barrier however, with its attendant cost, makes such an approach uneconomical for general application. It is also uneconomical to install thermal insulation with poor vapor protection because of its short life preceding failure. The engineer's problem is the design of an installation that will provide a reasonable life expectancy at a reasonable cost.

Not only does the vapor condensation inside the insulation cause ultimate failure but as the air spaces within the insulation become filled with moisture the thermal conductivity of the insulation is increased. For this reason, not only must the resistance to heat flow be satisfactory when the materials is new and dry, but it must also be satisfactory for some given period when it contains moisture. Therefore, design calculation must allow for some increase in conductivity values over those published for the material in its dry state. Also, since thermal characteristics are a function of the moisture content, the vapor barrier should be as carefully selected and designed as the primary thermal insulating material.

Factors Involved

To point out the factors involved, an example is shown in Figure 1. Assume the operating temperature of the pipe (or vessel) is 30° F. on the surface with 100 percent relative humidity, and the vapor pressure is 0.164 inches of mercury. The outer surface of the insulation on this pipe (or vessel) is sealed with a vapor barrier. The surrounding atmosphere is 90° F. with a relative humidity of 80 percent. Under these conditions the vapor pressure of the atmosphere is 1.100 inches of mercury. The difference between the inner and outer vapor pressure will be the force against the vapor barrier. This is 1.100 minus 0.164 which equals 0.936 inches of mercury. In more familiar terms this equals 0.464 psi, or 70.6 pounds per sq. ft. This force is pressing inward on the entire area of the vapor membrane, seeking to penetrate any crack, hole, or weakness. If the vapor does get through the barrier and goes into the insulation, its temperature becomes lower, and at some point toward the inner surface the vapor will reach its dew point. As previously mentioned, the continuation of this process will ultimately fill the air spaces in the insulation with water or ice. Although the process of moisture migration cannot be stopped it must be sufficiently retarded to obtain a reasonable economic life of the installation. This example has been stated in its simplest form and does not include; variation,

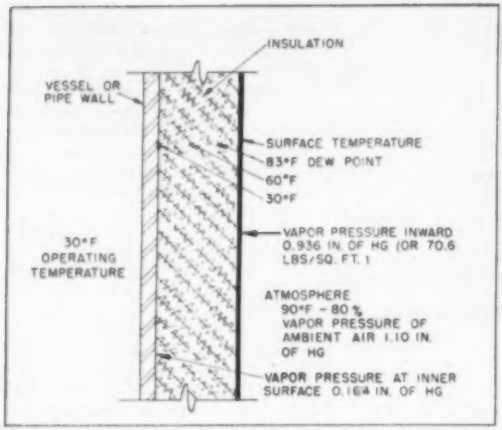
INSULATION
VESSEL OR PIPE WALL
SURFACE TEMPERATURE
83°F DEW POINT
60°F
30°F
VAPOR PRESSURE INWARD 0.936 IN. OF HG (OR 70.6 LBS/SQ. FT.)
30°F OPERATING TEMPERATURE
ATMOSPHERE 90°F – 80% VAPOR PRESSURE OF AMBIENT AIR 1.10 IN. OF HG
VAPOR PRESSURE AT INNER SURFACE 0.164 IN. OF HG

Figure 1. Vapor Pressure Diagram.

especially increases, in ambient temperature; proximity of bodies of water, spray ponds or escaping vapors; radiation from surfaces of nearby equipment or the sun.

One of the important considerations of the design for low temperatures is to specify sufficient insulation thickness to provide thermal resistance so that the outer surface of the insulation has a temperature above the dew point of the surrounding air during the warm summer. The reason: should this surface temperature fall below the dew point of the air the outer surface of the insulation would be continually wet due to condensation. Moisture in the liquid stage on a vapor barrier surface will increase its vapor migration rate, as well as cause sloppy appearance and possible damage from dripping water.

Three-Part Problem

The problem should be broken down into three parts. The first is the selection and design of the thermal insulation as determined by the conditions of the installation. The second is the design and selection of the proper vapor barrier to protect the insulation under the vapor conditions involved. The third is the design and selection of the proper weather barrier or outer protective coat. In some instances the vapor barrier and weather barrier will be one and the same material, whereas in other instances a separate vapor barrier and weather barrier may be used. It must be remembered that it is not enough that each perform its individual function, but in addition, each part of the installation must function harmoniously with the other parts.

The particular requirements of any installation will govern the selection of the type and manufacture of insulation most desirable in each instance. In most cases the physical properties are the deciding factor as to the proper insulation. Thermal insulation in itself is normally not very vapor resistant since its primary function is that of resisting heat flow. Some materials requiring binders to unite the mass into a cohesive shape may repel water quite satisfactorily but are very weak in their resistance to moisture vapor. Because all insulation used to retard the flow of heat to low temperature equipment or piping is subjected to moisture, it follows that any insulation used for this purpose must be resistant to damage by moisture. Under these damp conditions the insulation should resist rot, mold, softening or any action of disintegration due to presence of water.

The insulation must be able to resist the physical stress imposed upon it. When the pipe or vessel contracts, the insulation must be sufficiently flexible or properly installed to absorb the compression. Similarly, the insulating material must be able to withstand any other mechanical stresses to which it may be subjected, such as vibration, twisting or bending. In addition, the insulation must be able to withstand the forces of abuse exerted upon it from the outside. Insulation installed in an industrial plant may be walked upon or hit with ladders which may damage its vapor barrier, but it should be sufficiently strong to resist the ordinary abuse to which it may be subjected.

Not only must the insulation resist external stresses applied to it but it also must resist internal stresses. Temperature changes will set up stresses in the insulation itself. One excellent low temperature material possesses such characteristics that, if warmed suddenly, it may develop cracks from stresses caused by this rapid temperature change. All fibrous, granulated, or cellulated type materials may be subjected to internal stresses caused by ice crystals when formed in the air spaces.

In low temperature as in moderate temperature applications the ability of the insulation to resist the flow of electrical currents may be very important in the prevention of galvanic action which causes damage to equipment or piping. Of course, the material and method of fastening the insulation may determine whether such galvanic action will occur. Whenever metals dissimilar to the equipment or piping are used, care must be taken that sufficient electrical resistance is provided to eliminate the possibility of damage by galvanic electrical flow.

Problems of Securement

The securement of low temperature insulation to low temperature equipment and piping becomes, in many instances, a serious problem. In no case should the metal securement extend from the low temperature surface to the outside of the insulation. Steel has roughly 900 times and copper 9000 times the heat conductivity of insulation at low temperatures. A small projection of steel or copper from inside to outside provides a path of heat flow to the low temperature surface. This heat gain, although great, is not the important factor. The important factor is that this metal becomes cold, then ice forms around it to cause a break in the vapor barrier and provide a point of entry for moisture to destroy the insulation. Any metal which, due to necessity, must project beyond the surface of the insulation, should be insulated for a distance at least four times the thickness of the insulation. This is a rule of thumb. Actually the distance should be determined by the amount of heat the projection insulation will allow to pass into the extending metal, as compared to the amount of heat which will be transmitted by its cross section. The gain through the insulation should always be as nearly equal to that through the cross section as practicable. The end projecting through the protective insulation should be above the frost point.

One serious problem frequently overlooked in low temperature insulation is its possible contribution to fire hazards. Because all high temperature thermal insulation materials are fire resistant, the user of thermal insulation sometimes forgets that not all low temperature materials are equally safe. In many industries where fire-resistant

construction is required, low temperature insulations are used which are a potential fire hazard. In other instances, a fire-resistant low temperature insulation is coated with a hazardous vapor or weather barrier. Whenever low temperature insulations which are not fire resistant are used because of other factors which make them desirable, special care should be taken to cover them with a fire-resistant coating or jacket. If this is not practical then a sprinkler system or other protective devices should be provided. It is difficult to find a suitable fire-resistant material (none are fireproof), but materials are now available which are a definite improvement and which offer increased hope in the near future.

Requirements of the Vapor Barrier

Fundamentally, as mentioned previously, since the primary function of a vapor barrier is to prevent vapor from entering into the thermal insulation, its rate of vapor transmission should be low. However, for satisfactory service the vapor barrier must have other characteristics to enable fulfillment of its function. It must be properly secured to the insulation it is to protect. In the case of jacket materials a satisfactory vapor-sealed joint must be obtained; consequently, the cement or sealer used (and its method of application) is more important than the jacket itself. Where using plastic material, satisfactory adhesion to the insulation surface must be obtained and the material must cover without leaving pin holes and weak spots when dry.

Like the thermal insulation the vapor barrier must withstand the stresses imposed upon it without tearing, cracking, or chipping. It must also withstand mechanical impact such as that caused by walking upon it. Also, it must have sufficient tensile strength to resist shear and pull. It must withstand the maximum and minimum temperatures to which it is exposed without becoming brittle and cracking when cold, or becoming soft and running when warm.

Requirements for Weather Barrier

The vapor barrier may or may not be a weather barrier. In cases where a material is both a vapor barrier and a weather barrier, it must have sufficient properties to serve both purposes. It is not necessary for a weather barrier to have an extremely low vapor transmission rate where used over a vapor barrier.

The strength properties of the weather barrier should be sufficient to resist the stresses and loads imposed upon it. In addition, the barrier must be able to withstand the ravages of weather, the effect of which is one of the most difficult of all things to control. It must withstand all the elements such as rain, sleet and snow. Atmospheric temperatures in most sections of the country vary in excess of over 100° F., and the weather barrier must perform satisfactorily at the very highest temperature as well as the very lowest. It must withstand the radiation of the sun and the force of wind. In some areas the wind will pick up sand or grit so the weather barrier must resist this abrasion. It must also resist the attack of fumes and gases to which it may be exposed.

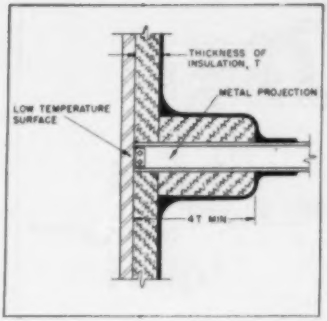

Figure 2. Application of Insulation to Metal Projection Attached to Low Temperature Vessel.

Special Requirements

Other materials are needed for the application of low temperature insulations which are not classified as thermal insulation, vapor barrier, or weather barrier.

One such material is an adhesive cement used either to adhere the insulation to a vessel or to cement the insulation to similar materials. These cements must have characteristics which will satisfactorily fulfill their function. The temperature with which they may come in contact is generally much lower than that to which the vapor, or weather barrier may be subjected because it is used on the inner surface of the insulation in contact with the low temperature vessel or pipe. A much greater strain is imposed on this cement when used with dual temperature service and extreme care should be exercised in its selection. When operating temperatures are lower than —50° F. or higher than 100° F. the use of asphaltic materials for this service should be questioned as they generally become hard and brittle at the lower temperature and may lose their grip at the higher one.

Other materials are used to cushion the insulation against vibration and abrasion. These again must be chosen with care. Used in joints they must remain elastic and maintain their adhesive properties at low operating temperatures. In cases where operating temperatures are below —50° it is necessary to have one material for the inner joints and another material which has better sealing and vapor resisting characteristics in the outer joints. To the writer's knowledge only a limited number of joint materials are usable in the range —50° to —300°, and they do not have the adhesive, vapor-resistance, and elastic properties of many of the adhesives suitable for the service down to —50° F.

Some of the necessary properties of the thermal insulation, the vapor barrier, the weather barrier, and adhesives have each been discussed. It is not always possible to use the best of each group for any particular application, since in some instances the material chosen is not compatible with the others. It should be remembered that materials selected must function together as a unit and each must work well with the others.

Testing of Insulation

The tests for insulation, vapor barriers, and weather barriers are important in the determination of those materials to be specified for any particular installation. The tests for insulation as listed in Part IV (Petroleum Refiner, June, 1952) may be used to advantage for the low temperature range as well as for the moderate temperature range.

Tests should also be devised to evaluate the properties of the vapor barrier and the weather barrier, since the proper selection of these materials is equally as important as the selection of the thermal insulation. (American Society for Testing Materials, Committee C-16, has tests in process to determine proper values for moisture vapor resistance.) It is wise to test the insulation, vapor barrier, and weather barrier in combination to be certain that they function together as a unit.

It should be kept in mind that tests for the most part will determine what materials should not be used, because, in most instances, no completely satisfactory material exists and the materials used are those which most nearly satisfy the desired conditions.

Again referring to Part IV the list of questions to be answered may also be used to advantage in the design of insulation for this temperature range.

Figure 3c illustrates the three funda-

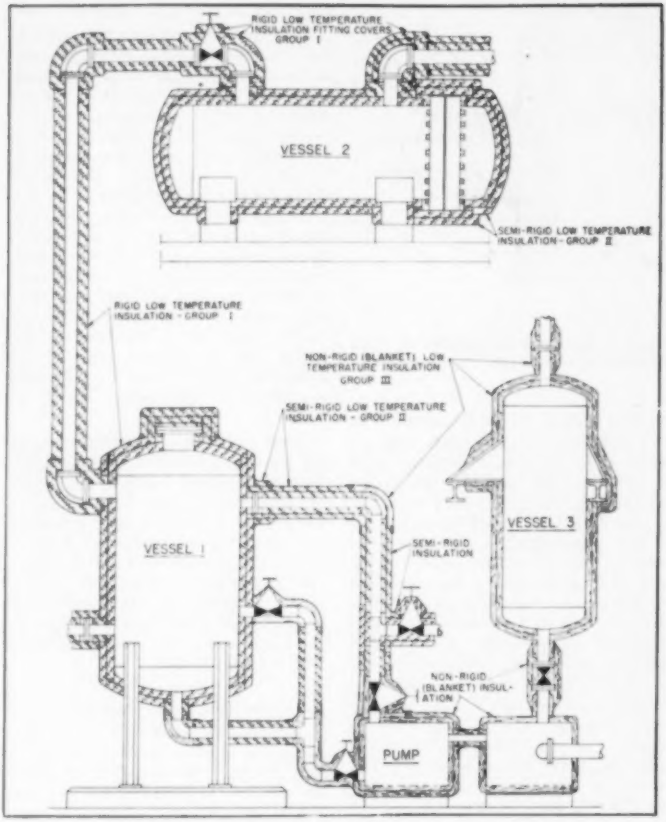
RIGID LOW TEMPERATURE INSULATION FITTING COVERS GROUP I
VESSEL 2
SEMI-RIGID LOW TEMPERATURE INSULATION - GROUP II
RIGID LOW TEMPERATURE INSULATION - GROUP I
NON-RIGID (BLANKET) LOW TEMPERATURE INSULATION GROUP III
SEMI-RIGID LOW TEMPERATURE INSULATION - GROUP II
VESSEL 3
VESSEL 1
SEMI-RIGID INSULATION
NON-RIGID (BLANKET) INSULATION
PUMP

Figure 3c. Schematic Details of Typical Equipment, Pump, and Piping.

mental types of low temperature materials which will be discussed further in Part VII. A rigid type of low temperature thermal insulation is indicated for vessel No. 1 and lines connecting vessels Nos. 1 and 2, a semi-rigid type is indicated for vessel No. 2 and lines from the pump to vessel No. 1, and a non-rigid or flexible type for vessel No. 3 and lines from vessel No. 3 to the pump. Following the decision regarding the materials to be used, it may become necessary to combine different types for various reasons. Time and facilities may not be sufficient to provide prefabricated or preformed shapes for irregular surfaces, so a more flexible type of material may be selected for application to such surfaces. Such a material, even though more costly under one set of conditions, may prove to be the less expensive under other conditions. The time saved by allowing the unit to begin operation promptly may amount to many times the cost of the more expensive method. This is especially true where emergencies are involved.

Dissimilar materials are not always restricted to adjoining surfaces, but may be used in combination to satisfy the required resistance. If it consists of two rigid materials, two semi-rigid, or one of each type, the combination may be easily obtained where the materials are manufactured under the Thomas Dimensional Standard System, since all of these materials will nest within each other. Where a flexible material is combined with either a rigid or semi-rigid, close tolerances are not required because the thickness can be reasonably well controlled through the pressure exerted in the application.

Design of Piping and Equipment

Although the insulation engineer may not be responsible for the design of piping and equipment, he *is* responsible for placing certain facts and information in the hands of such designers which will enable them to provide conditions more suitable for proper insulation installations. Many a plant has been designed which in its bare state was a thing of mechanical beauty and utility with unobstructed access to all areas. Following the application of adequate thermal insulation however, the original outlines became so distorted that the final appearance only remotely resembled the former and movement about the unit was made with difficulty. Sufficient spacing between adjacent piping is too often overlooked and such negligence can often double the cost of the insulation. Cradle supports should be placed on the outside of the insulation where possible, since every break through the insulation caused by projections is a potential failure. Anchors and guides should be designed to give the insulation applicator an even break because his is a difficult job even under the best of conditions. Suitable insulation supports must be located on long vertical lines and equipment to safeguard against slipping of the insulation. Nozzles and projections of equipment should be of sufficient length to permit tieing off and sealing the insulation behind the flanges and cross members.

End of Part VI. Part VII will appear in an early issue.

* * *

I Need Help!

Employe counselor asked for and got job of listening to other people's troubles.

AL REESE

Petroleum Refiner Staff

HE helps people to explode. He is R. L. B. Roessle, head of Employe Counseling Service for Standard Oil Company (N.J.).

He is a safety valve for the angry, a stimulant for the bored, an escape for the frustrated, a refuge for the fearful. He is perhaps the industry's most talented listener—and he created his own job.

An adult company in an industry just now emerging from the rugged individualism of brawling adolescence, Jersey Standard has long provided havens for troubled employes. For years Jersey people have been urged to take their problems to the medical and personnel departments and to their own supervisors. But there was a gap in the program. Who will discuss a job problem with his supervisor when his dislike of the supervisor is the very problem? Who will spread his intimate personal secrets before the eyes of a company doctor or personnel man?

Roessle observed this lack, asked and received permission to set up the counseling service, and began listening to people's troubles. That was in 1947, and he and his assistant, Miss Rita Hart, have now listened nearly 3000 times. More than 1500 employes have "blown their tops" about nagging wives, unfair bosses, wayward children. All of them absolutely sure their secrets would never leave the counseling room.

No less vital than secrecy is the voluntary basis on which the talks are conducted. The counseling room door is open to all, but nobody is pushed through it. And nobody receives a gift-wrapped solution to his troubles. He talks; the counselor listens. Then, gently, deftly, he is squared away to his problem.

The counselor's technique for the fearful is to help him confront his difficulty instead of running away. But for the bewildered, it is necessary to explore beyond the apparent difficulty. In one out of five cases the counselors are asked for one form of guidance only to find that the surface problem veils a deep emotional stress. For example, in Roessle's files is this case history of John X:

"Wants transfer. Hates his boss. On finding out that he also hates his father, it is made clear to him that there may be some relationship between the father attitude and his attitude toward his boss. It is recommended that he talk to his boss, which he does. He finds that his boss is quite different from what he had anticipated. He is still working in that department, and has been advancing steadily."

Counseling sometimes points a path away from employment with Jersey Standard. For example, there was the case of Harry L:

"Is unhappy in present job. Interests indicate outdoor, mechanical and scientific. He decides after discussing the situation at some length that he will become a veterinary and leave the company."

Many of the cases are less conclusive. The counselee stops the visit, and since the service is purely on a voluntary basis, the real problem is never ascertained. Such was the case of Miss X:

"Shows great falling off in work output . . . She is advised to take some YWCA courses and increase her circle of friends. Actually, the counselor did not feel at the time that there had been movement on the case. However . . . she has been showing consistent improvement . . . This is a case where the dynamics are not observable. We only recognize that something occurred in the counseling situation to enable her to make a better adjustment to the job situation."

For convenience, Roessle divides employe problems into five classifications:

- Vocational—on the job.
- Personality adjustment—where there is a minor psychological difficulty.
- Pre-retirement—for those who will soon be retiring.
- Information—for those concerned about jobs in general, company politics, etc.
- Supervisor counseling—to help supervisors with any unusual personnel problems.

Age, sex or length of service seem to have no bearing on the degree to which people need help, says Roessle. The only noticeable trend is that the younger age groups are, quite logically, more concerned with vocational and educational problems, the categories which embrace about 57 percent of the total interviews.

Older people who go to Roessle and Miss Hart have usually made adjustments in their working lives. Often they are just plain bored with a routine task which arouses no job pride, gives no satisfaction of achievement. Or sometimes they are lonely, often because of the loss of husband, wife or parent. The solution to either problem can be the stimulation of a

Robert L. B. Roessle

Rita V. Hart

ROBERT L. B. ROESSLE was born at Albany, N. Y., Aug. 8, 1897, and started in business as an office boy with a shipping concern. He enlisted in the Navy in World War I and became an ensign before the close of the war. In 1921, he started with Jersey Standard and went to Norway with one of the Norwegian subsidiaries. Within a few years he became manager of a Standard affiliate in Norway and after 16 years returned to the parent company in New York to become head of the Overseas Personnel Office, and then joined Foreign Marketing Coordination.

His position of advisor on employe development includes the counseling activity and the promotion of various employe relations techniques.

hobby, cultural pursuit or social activity.

The counselors occasionally hear problems which are referred to outside agencies better equipped to handle them. Marital difficulties, for instance.

Roessle and Miss Hart make no effort to divide the cases between themselves according to types of problems or the age or sex of the customer. An exception is the pre-retirement problem, usually handled by Roessle.

Roessle has no statistics which chart counseling successes against failures; if he followed up his cases he would destroy the confidential nature of the service. But on the whole, he believes most of his customers have gone away satisfied, and sometimes they tell him so later.

"Sometimes," he says, "it's just a cheery voice on the telephone saying 'Just thought you'd like to know I got that promotion.' That in itself may mean the happy ending to a case which just a few weeks ago was all tears and woe. And such a phone call is enough to make it all worthwhile."

RITA V. HART was graduated from New Jersey State Teachers College in June, 1943. She began her business career in a clerical position with the Federal Reserve Bank of New York. Shortly thereafter she was appointed education counselor. Realizing the need for additional psychology training, she, herself undertook an evening program toward a master's degree in vocational guidance at Columbia University, which she completed in June, 1949. She subsequently completed some courses toward a Ph.D. in psychology at Fordham University.

Before joining Jersey Standard, where she has been doing counseling and administering testing and rating programs for 2½ years, Miss Hart worked as personnel assistant.

* * *

No coke is safe from this combination

...Lagonda 1100 Series motor plus the right Lagonda cutter head

There's the simplest, most efficient combination for opening coke-clogged still tubes fast. Keen, long-lasting teeth on the cutter head unlock the iron grip of coke deposits, smash their way through clogged tubes without cutting tooth design in tube walls. And giving the proper spin in this combination is the powerful Lagonda 1100 Series motor. Ball thrust bearings at both front and rear plus exclusive Lagonda pressure lubrication insure long life and a short clean-out job. It will pay you to remember the combination that cuts down-time — clears coke deposits in no time ... Lagonda 1100 Series tube cleaners. And you'll find a Lagonda man is a "savvy" partner on your next coke-busting job. Call him, he'll be happy to help.

BULLETIN Y-29 ...
is crammed with interesting facts on how to cut down-time while clearing still tubes. Mailed on request.

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LAGONDA DIVISION, SPRINGFIELD, OHIO
Plants at: JEANNETTE, PA. • RIDGWAY, PA.
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Y2-5

REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the processing industry.

Coulter Presents Distillation Data

When K. E. Coulter isn't spending his time in Dow Chemical's Texas or Midland, Mich., plants doing development and production work, he's engaged in distillation work. The first of four parts of Coulter's article "Applied Distillation" begins on page 95 and adds another credit to his list of four articles which he has authored or co-authored, and published in the REFINER to date.

Whatever spare time Coulter has, he spends with his wife, Eleanor, and three children, or hunting and farming. His civic activities include serving as director and secretary of the local school board in Midland, plus representing his township on the county school board.

K. E. Coulter

Co-Authors Split in Selecting Hobbies

Gordon E. Langlois and John E. Walkey, co-authors of "Improved Process Polymerizes Olefins for High Quality Gasoline" on page 79, have some differences of opinion—at least, when it comes to hobbies. There's quite a stretch between Langlois' ice skating and tennis and Walkey's Marin Symphony orchestra and landscape gardening. Langlois throws in hiking, too. But whatever difference of opinion concerning hobbies exist between the two men, they disappear when they get together to write a paper like the one in this issue.

Walkey is a native of Butte, Montana, receiving his B.S. and M.S. degrees from the University of Washington, and his Ph.D. from the University of Texas. He joined California Research Corporation in 1945 and is presently a senior research engineer.

Gordon Langlois calls Burley, Idaho, his home town. He received his B.S. in chemistry from Northwestern University and his Ph.D. from the University of California. He joined California Research in 1943 and has been with them since that time engaged in research on the catalytic prosessing of light hydrocarbons, particularly polymerization, alkylation and isomerization.

Magnolia Authors Talk Of Carbon Deposition

"How Charge Stock Properties Affect Carbon Deposition in Catalytic Cracking," on page 109, is the work of two Magnolia Petroleum Company engineers who have spent lots of time getting acquainted with the intricacies of cat cracking. C. A. Duval, Jr., one of the Texas-born pair, hails from Austin, and graduated from his hometown school, the University of Texas, in 1941. That same year, he went to work for Magnolia at Beaumont, Texas. Married now, and father of a 12-year-old son and 18-month-old daughter, he worked in product control laboratories for two years and spent six more as a process engineer on Houdry and TCC units. At present, he is in charge of the light oil control section.

Corpus Christi-born L. S. Holmes spends his time hunting and fishing when he isn't working as a group leader in Magnolia's process control laboratories in charge of catalytic cracking pilot unit operations, or relaxing with his wife, young daughter and eight-month-old son. Holmes began working as a process engineer on catalytic cracking in 1948, and assisted in the start-up of three air-lift TCC units at Beaumont and one at Buffalo, N. Y. He is a member of AIChE.

Wolf's Head Chairman Dies

E. W. Chase, board chairman of Wolf's Head Oil Refining Company, died recently after several months illness. Chase had been active in the Wolf's Head organization since 1905.

John E. Walkey — Gordon E. Langlois — L. S. Holmes — C. A. Duval, Jr.

MORE PRODUCTS
FROM NATURAL GAS

Mathieson Chemical Corporation Plant
Doe Run, Kentucky

From Gabe, Kentucky, liquid hydrocarbons extracted from natural gas are piped to Doe Run. Here, at the rate of 450,000 gallons per day, they are converted into domestic bottled gas, natural gasoline, and "permanent" anti-freeze, as well as intermediates for the manufacture of plastics and synthetic fibres.

STONE & WEBSTER ENGINEERING CORPORATION

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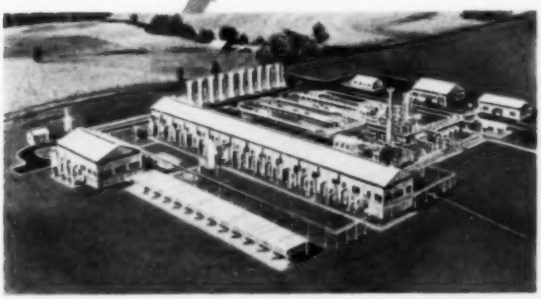


Hydrocarbon Extraction Plant
Tennessee Gas Transmission Company, Gabe, Kentucky

DEPENDABILITY IN CATALYSTS CANNOT BE SEEN

Top uniformity and dependability are available to you in Davison's microspheroidal (M-S*) or ground (DA-1*) synthetic fluid-type cracking catalysts. The accompanying photomicrographs show the physical characteristics of the DA-1 and new M-S catalysts produced in Davison's Cincinnati plant. Uniform physical and catalytic characteristics result from Davison's modern facilities and years of technical experience and research. Experienced Davison Field Service Engineers—complete laboratory facilities—are all part of Davison Dependability—Dependability with the big "D".

*T.M.T.D.C.C.

Progress Through Chemistry

THE DAVISON CHEMICAL CORPORATION

Baltimore 3, Maryland

PRODUCERS OF: CATALYSTS, INORGANIC ACIDS, SUPERPHOSPHATES, PHOSPHATE ROCK, SILICA GELS, SILICOFLUORIDES AND FERTILIZERS

John M. Campbell | Lawton Laurence | James A. Biehl | Robert G. Blick

BS & B Pair Team Up On Natural Gas Series

Two Black Sivalls & Bryson men, Lawton L. Laurence and John M. Campbell, combined their talents to produce the series "Dehydration of Natural Gas and Light Hydrocarbons Liquids," Part I of which begins on page 65. Laurence, director of engineering for BS & B, attended Cameron Junior College, and in 1941 graduated with a B.S. degree from the University of Okahoma. He was formerly employed by Carter Oil Company where he was engaged in research on drilling equipment and practices. He has been with the present company for eight years during which he has been active in the design of gas and oil processing equipment.

Iowa-Oklahoma Product

Campbell received his B.S. in chemical engineering at Iowa State in 1943, and then accepted a position with du Pont at Cleveland from which he was soon transferred to their atomic energy installation. In 1946 he became an instructor in chemical engineering at the University of Oklahoma until resigning in 1950 to complete work on his Ph.D. Prior to, and since receiving his Ph.D. degree in 1951, he worked for Black, Sivalls & Bryson on special dehydration problems and is now technical assistant to the oil and gas sales manager. Campbell's primary outside interest lies in athletics, and he is an active official in the Oklahoma high schools. He is married and has two sons.

Biehl Is Former Navy Engineering Officer

James A. Biehl, who authored the article "How To Reduce Phenol In Wastes From Catalytic Processes" on page 88, was barely out of college when he was called into the Navy, but apparently that didn't dim his interest in research and development.

Graduated from Indiana University in 1943 with a B.S. degree in chemistry, he joined The Ohio Oil Company as a chemist in the Experimental and Development laboratories located near Robinson, Ill.

Shortly afterwards, in 1944, he entered the Navy and served two years as an Engineering Officer afloat. Biehl is married and is the father of a four-year old daughter.

Blick Writes While On Location In Texas

Temporarily quartered in Brazoria, Texas, as he works on chemical plant development engineering for the Dow Chemical Company, Robert G. Blick, staff engineer for Lee Factors Company of Los Angeles, is the author of "Analytical Solution of McCabe-Thiele" beginning on page 105. This article is the fourth Blick has published in PR, having submitted single articles in 1949 and 1950, as well as a series of three in 1950.

"It seemed to me," wrote Blick regarding the current article, "that an analytical solution would be much easier for the crowded ends, after designing several high purity columns . . . I don't claim any originality for the formulas, although I haven't seen any for this special application before."

Active in ASME work, he gave a talk for the Hydraulics Division in 1950, and last year wrote a paper on "Interaction of Pressure and Bending at Pipe Flanges" which was delivered before the sixth annual conference at Tulsa.

Blick entered the industry early in 1942 through association with The M. W. Kellogg Company, and subsequently joined Project Engineering Company in New York. From 1940 to 1947 he studied at Cooper Union Night School—where he met Mrs. Blick. He has been on the West Coast for the past four years with C. F. Braun, Lockheed Aircraft, Southwestern Engineering and Lee Factors. During the war he spent two years as a radio theory instructor and as a fixed station transmitter engineer overseas with the Signal Corps, and designed some equipment for the Signal Corps.

Technical writing, radio, sound recording and music appreciation, wood and metal working are listed among his hobbies. Married, Blick and his wife have four children.

E. J. Tully, So-Vac Employe, Completes 50-Year Service

Edward J. Tully, superintendent of the Brooklyn Grease and Compounding department of Socony-Vacuum Oil Company, Inc., recently celebrated 50 years of service with the company. He was honored by his fellow employes at a foremen's dinner. Tully began his career in 1902 as an office boy. He worked his way up to the position of chief clerk and was transferred in 1918 to the company's Brooklyn packaging operation as assistant superintendent. He was later transferred to a light products refinery as superintendent and in 1939 returned to his original stamping ground as superintendent. He assumed his present position in 1949.

James Cosgrove, Continental Chairman, Honored By APIC

James J. Cosgrove, chairman of the board of Continental Oil Company and a founding member of the American Petroleum Industries Committee, was presented an engrossed resolution of appreciation for his 19 years' service on the Committee at the APIC's recent meeting.

The APIC resolution "expresses appreciation for the many invaluable contributions of Mr. Cosgrove to the work of this organization, and gives recognition to the enduring worth of his counsel and the splendid example of interest and enthusiasm he has given us during the period of his membership."

Presents $1000 Scholarship

W. A. Schlueter, president of Refinery Supply Company of Tulsa, has presented to Dr. G. L. Cross, president of The University of Oklahoma, another $1000 scholarship to be awarded to some worthy student in chemical engineering. This is the fifth to be presented as the William A. Schlueter Fellowship award.

The MONTH... in the INDUSTRY

30 Firms Organize Research Company on Fractionation

A non-profit company organized to compile and develop engineering information on fractionation problems has been named Fractionation Research, Inc., and is subscribed to by more than 30 oil, gas, chemical, and construction companies. At its initial meeting late last month at Oklahoma City, the group elected the following officers:

T. B. Hudson, Phillips Petroleum Company, president; D. W. Wilson, Arthur G. McKee Corporation, vice president; George H. Burrus, Anderson Pritchard Oil Company, vice president, and Paul J. Parker, Phillips Petroleum Company, secretary-treasurer.

Membership in the organization is open to individuals and companies interested in design engineering information useful in the construction and operation of fractionating columns. Members will bear the cost of the new company through contributions based on the quantity of output of oil or natural gasoline, or on net assets if the member is not a petroleum company.

"Hot" to "Cold" Production

Conversion from "hot" to "cold" synthetic rubber with a production increase of 30,000 long tons annually, has been announced by the United States Rubber Company's Naugatuck Chemical Division for its Port Neches, Texas, GR-S synthetic rubber plant.

Warren Kraft, F. L. Hartley Elected To Top CNGA Offices

Warren H. Kraft, Honolulu Oil Corporation, has been installed as President of the California Natural Gasoline Association for the fiscal year of 1952-53. Fred L. Hartley, Union Oil Company of California, was elected vice president and E. R. Millett, Jr., was again appointed as secretary-treasurer at the annual meeting of the Board of Directors recently in Los Angeles.

Directors to serve for 1952-1953 are: D. R. Arnold, The Superior Oil Company; M. L. Arnold, Richfield Oil Corporation; F. W. Borden, Sunray Oil Corporation; R. O. Boykin, Fullerton Oil Company; A. H. Bradford, West Coast Refining Company; F. E. Bradley, C.C.M.O. Company; F. C. Brunner, C. F. Braun & Company; C. L. Case, Continental Oil Company; L. V. Cassaday, Lomita Gasoline Company; F. J. Colton, Tide Water Associated Oil Company; D. W. Darnell, The Fluor Corporation; F. F. Doyle, Pacific Gas & Electric Company; J. T. Doyle, Shell Oil Company; H. L. Eggleston, Analyst; R. C. Enderly, Wilmington Gasoline Company; P. E. Foote, Petrolane, Ltd.; M. L. Fort, Pacific Lighting Gas Supply Company; C. D. Gard, Union Oil Company of California; R. D. Gibbs, Union Oil Company of California; Wes Hammond, Worthington Pump & Machinery Corporation; John Hancock, The Hancock Oil Company; R. W. Heath, Signal Oil & Gas Company; W. J. Heinz, Ingersoll-Rand Company; J. C. Herron, Shell Oil Company; R. J. Hull, California Research Corporation; C. L. Hutchings, Tide Water Associated Oil Company; M. W. Kibre, General Petroleum Corporation; Wm. A. Kirk, California Southern Oil Company; Grove Lawrence, Southern California Gas Company; H. R. Linhoff, Richfield Oil Corporation; Paul Magee, The Ohio Oil Company; S. F. Magor, The Superior Oil Company; P. S. Magruder, General Petroleum Corporation; Geo. C. McLaren, Standard Oil Company of California; N. H. Mull, The Texas Company; H. W. Parmelee, Consultant; H. M. Paulsen, The Norwalk Company; W. W. Robinson, Jr., The Texas Company; T. L. Taggart, Standard Oil Company of California; J. B. Taylor, Signal Oil & Gas Company; R. W. Todd, Pacific Lighting Gas Supply Company; R. S. Tulin, Shell Oil Company; E. W. Walker, Western Gulf Oil Company; L. K. Whittier, Belridge Oil Company; D. M. Wolfe, Standard Oil Company of California, and C. B. Kimberlin, Seaboard Oil Company of Delaware.

Continental Buys Detergent Plant from Stepan Chemical

Continental Oil Company has announced the purchase of a synthetic detergent plant from the Stepan Chemical Company. The plant, located in Chicago, will be operated by Conoco's petrochemical department and will continue to manufacture industrial synthetic soaps. The plant is one of the largest producers of bulk synthetic detergents in the Midwest.

Acquisition of the chemical plant gives Conoco a fully integrated operation for manufacturing synthetic detergents for the soap industry.

Paul Geiser, former coordinator of petrochemical technical services for Conoco in Baltimore, has been transferred to Chicago as plant superintendent. Herbert Davis has been moved from the company's general offices in Ponca City to become office manager.

Gerald J. Smith Elected to Catalytic Construction Board

Gerald J. Smith has been elected to the Board of Directors of Catalytic Construction Company. He is manager of the Estimating and Cost Control Department and is responsible for the preparation of all proposals and contracts. Smith joined the company when it was formed in 1946, and prior to that, he was with the Sun Oil Company.

Kraft

Hartley

"Taking Stock" A New Feature

For a number of years we have been tabulating "Trends of Operations and Changes in Stocks" in the news section of our magazine. This month we are unveiling a new department, "Taking Stock" on page 104 which presents in graphic form the position of crude oil and refined product stocks in the past and present year. The accompanying tables go a step further in presenting the position and production of these stocks for the past two years.

Each month you will be able to follow the trends of crude oil and refined products. These figures form the basis for predicting trends in the future. If you have wondered about the effect on refined products of such factors as strikes, seasons, and national emergencies, you will find the answer here.

API Moves For Improved Supply-Demand Reporting

The American Petroleum Institute is arranging for monthly Census Bureau reports on secondary stocks of four principal products, and also taking steps to enable the Bureau of Mines to make data in its monthly petroleum statement and natural gasoline report more nearly current. All refiners are being asked by the API statistics department to return monthly Mines Bureau questionnaires to the Bureau on the 25th of the month following that reported on. With the Bureau releasing reports by the 5th of the month, data then would be only five or six weeks old, instead of some eight weeks, on reaching the industry.

Then, companies reporting primary storage figures to the Bureau for the monthly petroleum statement are being asked to supply the Census Bureau at the same time, data on their secondary stocks of gasoline, kerosine and distillate and residual fuel oils.

These figures would be issued as district product totals. The plan is to include stocks of jobbers and distributors, size of these inventories to be arrived at by as wide a sampling as possible by the Census Bureau.

Sinclair Promotes Fairlie To Lubricants Research Head

Sinclair Research Laboratories, Inc., has announced that M. R. Fairlie has been promoted to Director of Lubricants Research for Sinclair Research Laboratories. Fairlie was assistant director of lubricants research prior to his appointment and has been with Sinclair for 25 years. He has been connected with lubricants both in development and research for the past 18 years.

In his new position, Fairlie will cover the direction of research and development work on lubricating oils, greases, waxes and cutting oils.

Deep Rock Promotes Kiehn, Harrison At Cushing Plant

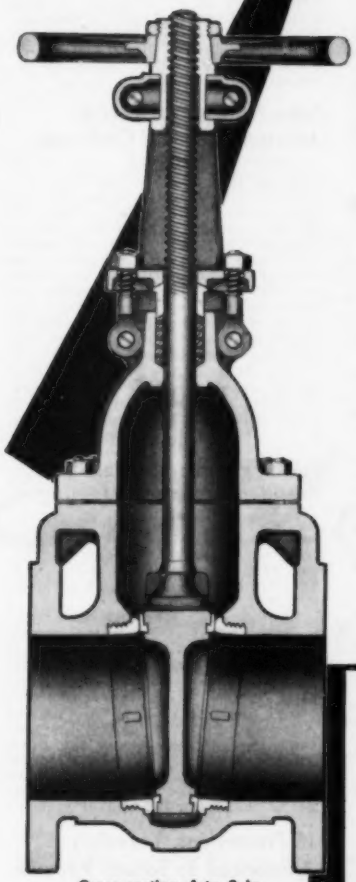
Robert L. Kiehn has been promoted to maintenance supervisor and Charles W. Harrison has been promoted to shift supervisor at Deep Rock Oil Corpora-

cut the high cost of corrosion

IN MANY SERVICES...WITH

CRANE *Ni-Resist*

CAST IRON GATE VALVES



Cross-section 4 to 8 in. sizes; bolted bonnet joint; flanged ends.

Here is a line of "cast iron" gate valves with a special talent for resisting corrosion, erosion and wear. Use them with safety where the strength of ordinary cast iron is adequate—in soda and sulfate pulp mill service—on creosote lines in wood treating processes—for handling sour distillates and crudes in petroleum refining—and many similar services.

Clue to the extra staying-power of Crane Ni-Resist Cast Iron Valves is in their make-up (approximately 14% nickel, 2½% chromium, and 6% copper)—and in their 18-8 Mo Alloy Steel stem and seating faces. Not to be overlooked is the fine Crane design that gives you a strong body and bonnet without excessive weight, a well-proportioned stem with precision-cut threads, a sturdy yoke, and the dependable disc-stem connection that assures smooth operation and tight seating of the solid wedge disc. Ask your Crane representative for full details, or see your Crane Catalog.

THE CRANE NI-RESIST LINE

Working Pressures:
Cold Water, Oil, or Gas, Non-shock
Screwed Valves—225 pounds
Flanged Valves—200 pounds

Available in sizes ½ to 8 in. All have solid wedge disc, with outside screw and yoke. Sizes ½ to 3 in. have clamp type bonnet joint and one-piece bolted gland. Sizes 4 to 8 in. have conventional bolted bonnet joint and two-piece bolted gland.

No. 1671 with Bolted Bonnet Joint, Flanged ends only. Sizes 4, 6 and 8 in.

No. 1670 with Clamp Type Bonnet Joint with screwed ends. Sizes ½ to 2 in. Also with flanged ends 1 to 3 in.

***The Complete Crane Line Meets All Valve Needs. That's Why* More Crane Valves Are Used Than Any Other Make!**

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

The Month...

tion's Cushing, Okla., refinery. Kiehn came to work for Deep Rock in 1948 after graduating from Oklahoma A & M College. Harrison was formerly pilot plant chemical engineer at the company's research and development plant in the Cushing refinery. He is a graduate of Oklahoma A & M and joined the company in 1948.

Preparations Underway For Oil Progress Week Observances

The Oil Industry Information Committee of the American Petroleum Institute has announced details of its plans for the fifth annual Oil Progress Week to be observed October 12-18, inclusive. According to the committee, the sole purpose of the observances is to help the American people get a better understanding of the oil industry.

Parades, speeches, radio broadcasts and television shows, luncheons, dinners and other gatherings of civic and community leaders, open houses, essay contests, exhibits, special editions of newspapers and other events are all included in the committee's plans for the week. A new souvenir booklet is being completed now and will be distributed during Oil Progress Week at refineries, service stations and other places where visitors will be taken on tours and given a first-hand view of the industry's operations.

The Oil Industry Information Committee's newest motion picture "Crossroads, USA," produced in Hollywood, will be available for its premiere in advance of Oil Progress Week. Another motion picture, "2 Equals 3," is almost ready for release and also will be used during the week. See page 47.

Eleven New Jersey Counties To Get API School Materials

As a result of conferences with state educational administrators in Trenton, N. J., plans are now complete for providing American Petroleum Institute school materials to public, private, parochial and vocational high schools in eleven New Jersey counties, the New Jersey Oil Industry Information Committee has announced.

The schools are being offered the material through their local Oil Industry Information Committees in order to provide students and teachers with a better understanding of the contributions of industry, and particularly the petroleum industry, to local and national life, and to provide local oil men with a closer contact with his community schools so he can be of help to the educators.

Phillips Employes Turn In Million Accident-Free Hours

Employes of Phillips Petroleum Company's refinery at Phillips, Texas, completed one million consecutive manhours without a lost-time accident recently. The safety period, which started January 30, 1952, is the fourth such accomplishment in the refinery's history. The plant has received two certificates of achievement from the American Petroleum Institute, and has also been awarded the Joseph A. Holmes award, presented by the United States Bureau of Mines. George E. McKenna is superintendent at the refinery, V. C. Cavin is assistant superintendent, and A. W. Sweeney is director of equipment inspection and safety.

Indiana Standard Makes Three Changes in Sales Department

Standard Oil Company (Indiana) has made three personnel changes in the general manager's office of the sales department in Chicago. H. W. King has been appointed manager, personnel department. J. H. Lind has been promoted to assistant manager, personnel department, and Victor Duch has been named personnel supervisor. Prior to their present appointments King was personnel assistant to the general manager of sales, Lind was personnel supervisor, sales department, and Duch was assistant upervisor, labor section.

THE OIL MAN'S CALENDAR

AUG. 7– 8	Western Petroleum Refiners Asso., Regional Meeting, Hotel Book-Cadillac, Detroit, Mich.
25–27	Twelfth Annual Appalachian Gas Measurement Short Course, West Virginia University, Morganatown, W. Va.
SEPT. 5– 6	Fourth Pre-Conference ISA Instrument Maintenance Clinic, Cleveland, Ohio, Case Institute of Technology.
8–12	ISA Conference and Exhibit, Cleveland, Cleveland Auditorium.
10–12	National Petroleum Assn., Annual, Atlantic City, The Traymore.
11–13	American Institute of Chemical Engineers, Palmer House, Chicago.
14–19	ACS, National (Petroleum Division), Atlantic City, The Traymore Hotel.
25–26	Western Petroleum Refiners Assn., Regional Meeting, Hotel Henning, Casper, Wyo.
OCT. 1– 3	South Central Region, National Assn. Corrosion Engineers, New Orleans, La., Jung Hotel.
6	Independent Natural Gas Association of America, Annual Meeting, Fontenelle Hotel, Omaha, Neb.
9–10	California Natural Gasoline Assn., Annual, Los Angeles, The Ambassador.
12–18	Oil Progress Week.
13–15	Texas Mid-Continent Oil and Gas Association, Thirty-Third Annual Meeting, Hotel Texas, Ft. Worth, Texas.
16–17	Western Petroleum Refiners Asso., Regional Meeting, Garrett Hotel, El Dorado, Ark.
19	National Gasoline Association of America, Southern Regional Meeting, The Blackstone Hotel, Tyler, Texas.
20–24	National Safety Council, National Safety Congress and Exposition, Chicago, Conrad Hilton Hotel.
20–21	Independent Petroleum Asso. of America, Annual Meeting, Mayo Hotel, Tulsa, Okla.
24	Natural Gasoline Association of America, Regional, Blackstone Hotel, Tyler, Texas.
Wk. of Oct. 27	AGA Annual, Atlantic City, Auditorium.
NOV. 9–13	Oil Industry Information Committee, Conrad Hilton Hotel, Chicago.
10–13	API Annual, Chicago, Conrad Hilton Hotel and Palmer House.
21	Natural Gasoline Association of America, Regional, Herring Hotel, Amarillo, Texas.
DEC. 7	Natural Gasoline Asso. of America, Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo, Texas.
7–10	AIChE, Annual, Cleveland, Hotels Cleveland and Carter.

Gulf Research Announces Chemistry Division Changes

The Chemistry Division of Gulf Research & Development Company at Harmarville, Pa., has been divided into a Product Division and a Process Division. This announcement was made recently by Dr. Paul R. Foote, vice president in charge of research for Gulf Research, who said the change would provide greater efficiency and effectiveness in carrying out process and product phases of the company's research activities. Dr. H. A. Ambrose has been appointed director of the Product Division; Dr. C. W. Montgomery has been named director of the Process Division with W. C. Offutt serving as assistant director.

Sohio Names Collacott As Assistant To Board Chairman

Robert H. Collacott, who joined Sohio in 1920, has been named an assistant to the chairman of the board of The Standard Oil Company (Ohio). He has been manager of marketing research since 1949, and will have special responsibilities in the field of economics. The enlarged planning activities in connection with Sohio's current expansion programs, as well as the increasing complexity of economic problems facing the company, occasion the addition to the chairman's staff, it was stated. For 18 months during World War II, Collacott served as chief of the price section, petroleum products division, Office of Price Administration, in Washington, D. C.

Edison Wheeler Elected ISEA President at Annual Meeting

The Industrial Safety Equipment Association held their annual meeting recently at Homestead, Hot Springs, Va., and elected president Edison L. Wheeler, of Wheeler Protective Apparel Company.

Elected also at the meeting were S. C. Herbine, Willson Products Company, vice president; J. B. Davies, Mine Safety Appliances Company and F. R. Davis, Jr., Davis Emergency Equipment Company, trustees. J. A. Brewer, Industrial Gloves Company and G. M. Glidden, Acme Protection Equipment Company carry over as members of the Board while Charles H. Gallaway, American Optical Company, ISEA president for the past two years, continues as a member of the Board for another year.

15 Promotions, Transfers Announced By Socony-Vacuum

Promotions and transfers involving 15 members of the Refinery Engineering Division of Socony-Vacuum Oil Company, Inc., have been announced. Roy M. Owens, chief project engineer, has joined Standard-Vacuum Oil Company as managing director of Stanvac's new refining subsidiary in Melbourne, Australia. Jesse C. Howard, in charge of the operating group, also has joined Standard-Vacuum and will be manager of the Altona refinery.

Harold C. Rothe, in charge of the maintenance group, is on leave to assist Vacuum Oil Company, Ltd., organize and train a staff to take over operation of Vacuum's new refinery at Coryton, England, which is scheduled to go on

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● Wherever oil is refined—here in America and in the far places of the world—oil men recognize the McKee name as a symbol of engineering integrity.

Refiners know McKee as a source of sound, practical engineering that comes only from long experience and thorough, up-to-date knowledge. They know the conservative business methods which have always characterized this company's activities. They know McKee as an organization with the scope and resources to undertake any refinery project, large or small, and carry it through to completion with efficiency and integrity.

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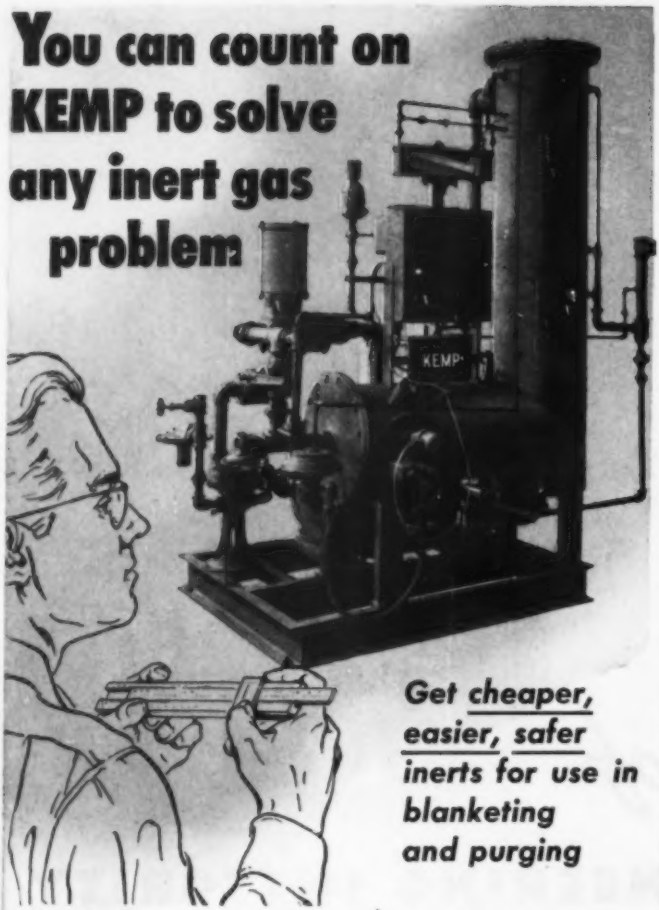
You can count on KEMP to solve any inert gas problem



Get cheaper, easier, safer inerts for use in blanketing and purging

DAY AFTER DAY Kemp users throughout the petroleum industry report: Kemp Inert Gas Generators, unlike old-fashioned makes, are fast-starting, easy-to-operate . . . save both time and money by reducing costly warm-up period necessary for starting. And every Kemp unit is designed to maintain an *exact analysis* of chemically clean inert gas . . . *regardless* of demand, *regardless* of your blanketing or purging requirements. You can't go wrong when you specify time-tested Kemp Inert Gas Generators.

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The Kemp Industrial Carburetor, standard equipment and the very heart of every Kemp installation, assures you complete combustion . . . without tinkering . . . without waste. Uses ordinary gas right from mains. Every Kemp Design includes complete up-to-the-minute fire checks and safety devices. Why not find out how Kemp can help you with your problems?

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INERT GAS GENERATORS

Write for Bulletin I-10 for technical information

THE C. M. KEMP MFG. CO.
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The Month...

stream late this year. R. E. Redfield, manager of manufacturing for Socony-Vacuum Francaise, will return to the United States in August to become head of the maintenance group of the Refinery Engineering Division.

Austin C. Brightman, assistant chief project engineer, has been advanced to project engineer, and Edward T. Maples, a group leader, will become assistant chief project engineer. Roger VanZytveld, in charge of the construction of a TCC unit for Deutsched-Vacuum Oel, A. G., at Bremen, Germany, and Thomas D. Owens have been promoted to group leaders in the project engineering section. Norman Lockwood, head of the maintenance department at the company's Brooklyn refinery, has been transferred to the Refinery Engineering Division as a project engineer.

Norman Rector Joins Staff Of Walco Engineering Firm

Norman K. Rector has joined the staff of Walco Engineering and Construction Company as chief design and process engineer with the Tulsa firm. From 1950 until joining Walco, Rector worked as an independent consulting engineer in the natural gasoline plant field. Included in his earlier work is service with Petroleum Engineering, Inc., and Gregg-Tex Gasoline Corporation. Rector, who studied engineering at Oklahoma A. & M. College, started in the petroleum field with the Marland Oil Company at Ponca City in 1926. Rector has been responsible for the fundamental design of some 50 complete gasoline plants and refinery vapor recovery units and more than 60 major plant extensions.

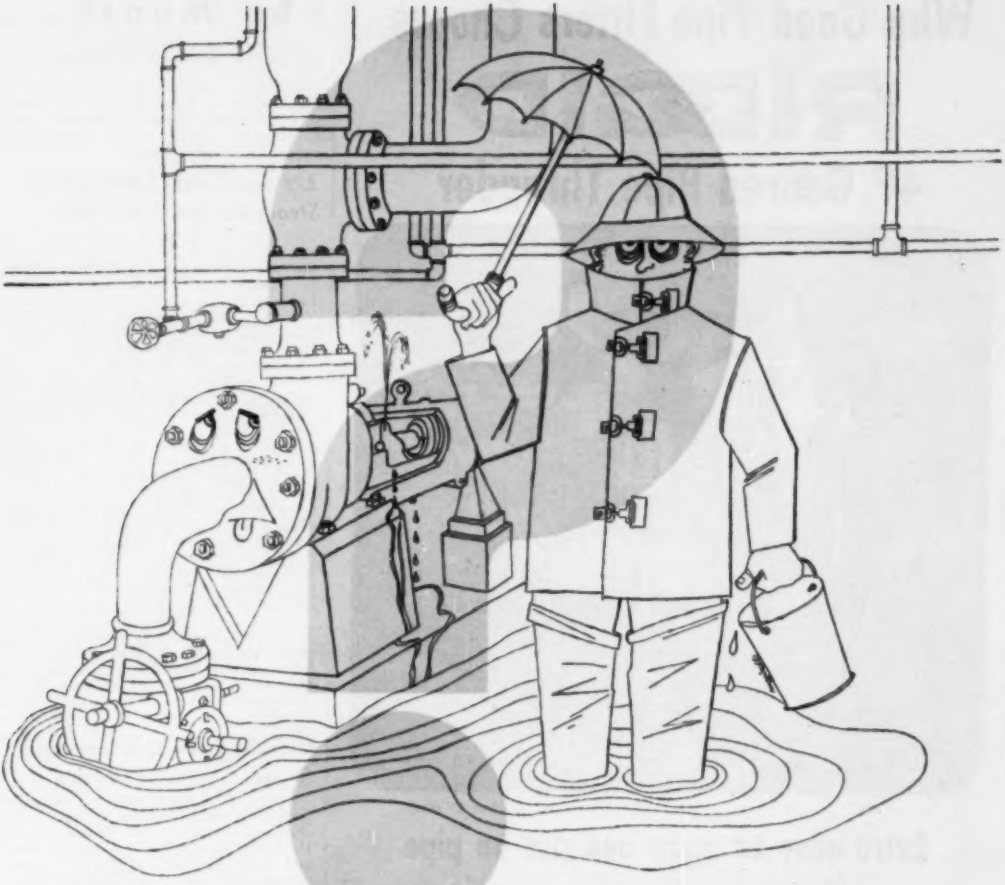
Rector

AIEE Subcommittee to Hold Special Technical Conference

The American Institute of Electrical Engineers subcommittee on Electrically-Operated Recording and Controlling Instruments will hold a two-day special technical conference in Philadelphia at the Benjamin Franklin Hotel on November 17 and 18. The purpose of the conference is to educate and stimulate interest in the design, theory of operation and application of electrically-operated recording and controlling instruments and to familiarize engineers with the recent advances in the metering and control of industrial processes which has largely been made possible by the utilization of new electrical recording and controlling techniques.

Safety Equipment Men Elect Edison Wheeler, President

At a recent meeting in Hot Springs, Va., the Industrial Safety Equipment Association elected Edison L. Wheeler, Wheeler Protective Apparel, Inc., president. Also elected were S. C. Herbine, Willson Products, Inc., vice president; J. B. Davies, Mine Safety Appliances Company, and F. R. Davis, Jr., Davis



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If you've got hip boots, a bucket and a standby maintenance crew with nothing to do, why bother with a BJ Mechanical Seal? Take a devil-may-care, every-pump-for-itself attitude and let the packing fall where it may. Or if your maintenance department enjoys a "Quick-save-the-dikes" sort of life, they will have great fun poking in packing before the stuff completely goes.

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The Month...

Emergency Equipment Company, trustees.

ISEA membership is composed of manufacturers organized to exchange ideas on industrial safety equipment and to solve problems of interest to the safety equipment industry.

API Auto Safety Survey Shows Steady Decline in Accidents

The steady decline in accidents involving trucks and automobiles operated by the oil industry continued during 1951, according to the American Petroleum Institute's Twentieth Summary of Motor Vehicle Accidents recently released. The 1951 accident frequency rate of 18.6 per 100 vehicles is the lowest in five years. The rate of 1.22 accidents per 100,000 vehicle miles is the lowest since 1945 and marks the fourth consecutive year in which there has been a decrease in this category.

Data in the summary represents the collective experience of 213 companies that operated 80,356 motor vehicles during the year. Of the total number of companies reporting, 156 maintain complete mileage records. These indicated that 64,160 vehicles that they operated during 1951 traveled 1,037,391,000 miles and were involved in 12,667 accidents. The vehicles had an average of one accident in 81,897 miles of travel.

Those reports that contain separate information covering passenger cars only show that 21,987 of them traveled 148,841 miles per accident. Trucks reported separately, of which there were 28,261, averaged 58,493 miles of travel to each accident.

Gulf Research, Development Divides Chemistry Division

Gulf Research and Development Company has divided its Chemistry Division into a Product Division and a Process Division for greater efficiency and effective in carrying out both phases of research activities. Activities of the Process Division will be devoted principally to new products development and to improving existing products. It will include a Product Development section, an Analytical section, an Entomology section, and a Service and Supply unit.

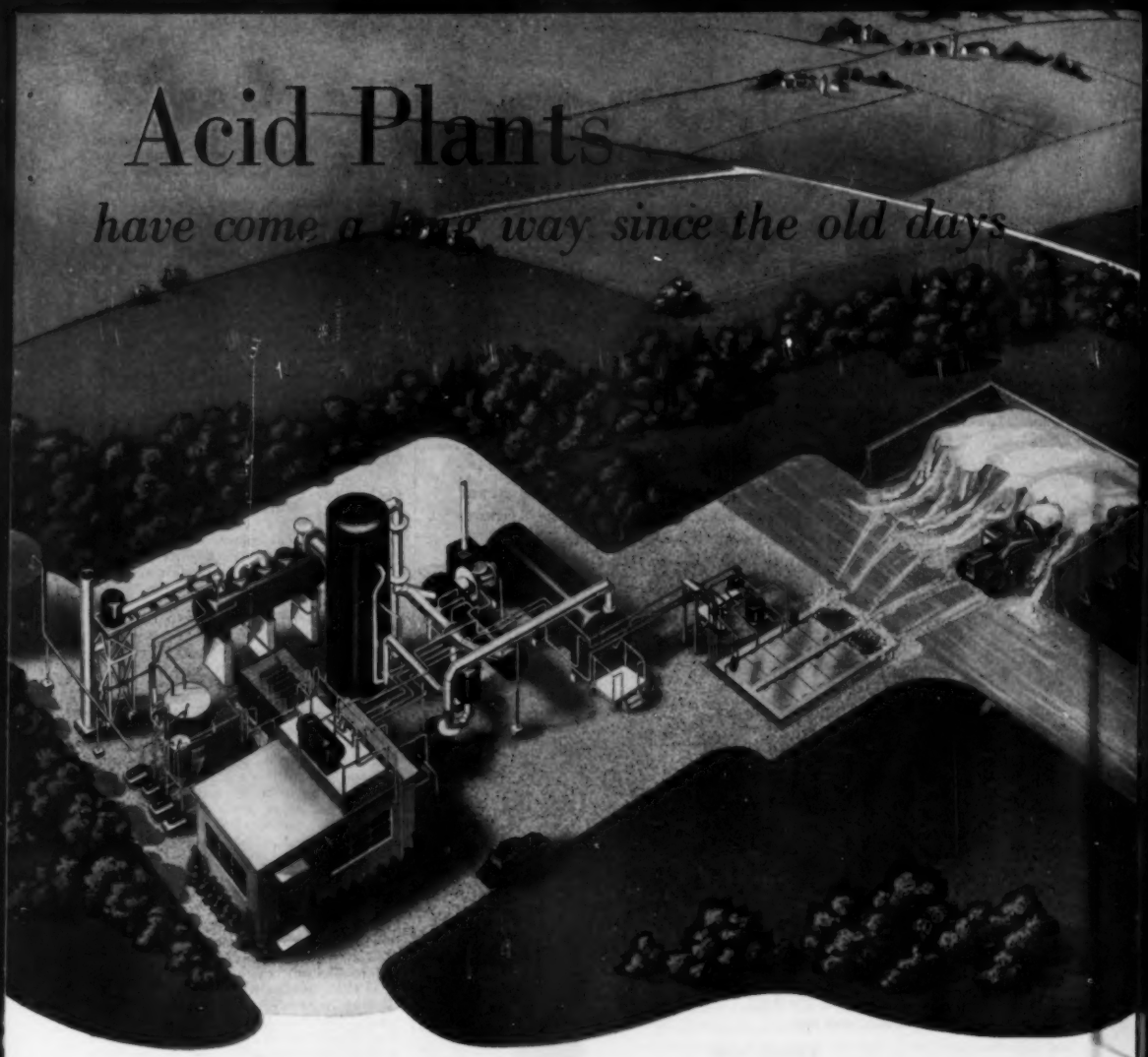
The Process Division is divided into three primary sections: 1) Refinery Process, concerned with refining methods and technology and operation of large scale pilot plants; 2) New Process section, engaging in new refining processes development, and 3) Petrochemicals section, for further research in the rapidly expanding petrochemical field.

BM Survey Shows Motor Gas Octane Ratings Slightly Up

Premium- and regular-price motor gasolines sold at United States filling stations last winter had octane ratings slightly higher than those of the summer of 1951, but failed to attain the record levels of gasolines surveyed during the winter of 1950-51, according to the semiannual survey report released by the Bureau of Mines. The report, latest in a series of surveys made by the Bureau in cooperation with the American Petroleum Institute, shows that

Acid Plants

have come a long way since the old days



At the turn of the century, virtually all sulfuric acid was made by the chamber process. A 50-ton per-day unit was a large installation and chamber acid had a maximum strength of 77 per cent.

Today's contact acid plants are a far cry from the old days. Units are modern and functional in design—efficient and reliable in operation. Single units producing up to 500 tons per day are becoming commonplace and acid of any strength is produced.

Chemico is responsible for many of the developments that account for this vast improvement. Chemico pioneered and pointed the way in the use of—

a. Pre-molten brimstone and spray sulfur burners

b. Pre-dried air for combustion of sulfur

c. Centrifugal blowers and pressure sulfur furnaces

d. Boilers to utilize waste heat of sulfur combustion

e. Economizers to utilize converter heat

f. Highly efficient, non-poisonable vanadium catalyst

g. Quench converters for high catalytic conversion

h. Acid wastes for production of fresh acid

These advances resulted in simpler, more reliable plants—higher efficiency—lower investment—conservation of manpower. Today more than ever, Chemico designed and built plants are profitable investments.

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Chemico plants are profitable investments

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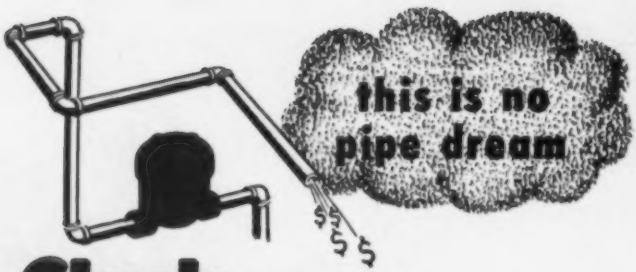

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If dollars are running through your steam lines it's time Clark Controls took over. Water in steam lines wastes fuel, cuts efficiency and adds greatly to maintenance costs.

Clark Steam Traps, with Duo-Stop Leverage, drain *twice* the condensate of ordinary traps. Clark Controls on your lines is truly like money in the bank. Write us for full details.

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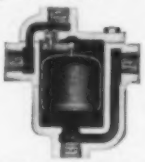

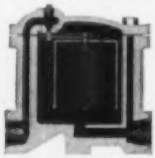

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SERIES "60" Inverted Bucket Trap

Choice of horizontal or vertical inlet or outlet. For pressures up to 150 P.S.I. "Clark-loy" guided disc and seat.

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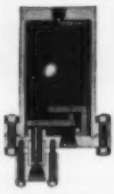
For continuous flow drainage. Pressures up to 600 P.S.I. Sizes ½" to 2". External discharge valve; "Clark-loy" disc and seat.



THE CLARK MANUFACTURING COMPANY
1847 East 38th St. • Cleveland 14, Ohio

The Month...

octane values of gasolines sold during the winter of 1951-52 are virtually the same as values of motor fuels surveyed during the summer of 1950. In volatility characteristics, the winter gasolines have changed very little.

A total of 4206 samples collected from service stations throughout the country, representing the products of 136 large and small companies, showed the premium-price motor fuels to have an average octane rating of 90.0 by the research methods and 82.0 by the motor methods. Regular-price gasoline has an average octane rating of 83.1 by the research methods and 78.1 by the motor method.

Joint Five-Year Research Program Gets Underway

A five-year research program on plate efficiencies in fractionating towers, a cooperative project between the American Institute of Chemical Engineers and 25 chemical, petroleum, and engineering organizations, was recently begun, according to an announcement of the Research Committee of the chemical organization. The program, supported by $64,000 in contributions from the cooperating companies for the first year, will be carried out at the University of Michigan, University of Delaware, and the Polytechnic Institute of Brooklyn.

The research projects will cover a basic investigation of the fundamentals of tray efficiency, both in fractionation and absorption. As the program is now planned, the initial work will cover the effect of system properties on tray efficiencies. Later work will include tray design and column hydraulics.

Askew Named Assistant at Sun Oil's Marcus Hook Plant

Sun Oil Company recently appointed W. T. Askew as assistant manager of its Marcus Hook, Pa., refinery. John S. Thompson will succeed Askew as superintendent of the refinery.

A 1931 graduate of Texas A. & M. College in chemical engineering, Askew joined Sun Oil as a chemical engineer but has served as foreman of a Sun Oil aviation gasoline plant and as assistant superintendent in charge of gas recovery and alkylation.

Thompson, a Princeton graduate in chemical engineering, and also a Sun Oil employe since 1931, has served with The Texas Company and E. I. duPont de Nemours.

Charleston AIChE Group Reports On Lecture Series

An inexpensive but authoritative method of bringing to chemical engineers in industry the latest developments in their fields is described in a recent report on advanced study courses on a local level, released by officers of the Charleston, W. Va., Section of the American Institute of Chemical Engineers. The report tells how the Charleston Section set up a series of lecture courses by chemical engineering experts in distillation and heat transfer, during the fall of 1951 and the spring of 1952.

The local group, by charging $6 for eight lectures, was able to pay lecture

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and his number is CHAPMAN List 960

Tough — that's the word for this small Chapman Gate Valve with the forged steel body and yoke. For no matter what job you put it on, within its remarkable capacity-range, you'll find it *tougher than the toughest conditions!*

That's right, *tougher* . . . because seat rings are hardened stainless steel . . . because wedge-faces are *superhardened* by Chapman's exclusive Malcomizing Process . . . and because the stem and wedge gate connection has been given extra strength to meet any extra stress.

So no matter what your job for small forged steel gate valves, Chapman's List 960 is the one you can bet on to "lick all comers." You can get it in sizes from ½" to 2" . . . equipped with rising stem, either with yoke as shown, or with inside screw. Bonnet joints are gasketed or metal-to-metal. Pressure range: 2,000 lb. at 100° F., to 380 lb. at 1,000° F. For higher pressures, specify List 990. Write for Catalog No. 10.

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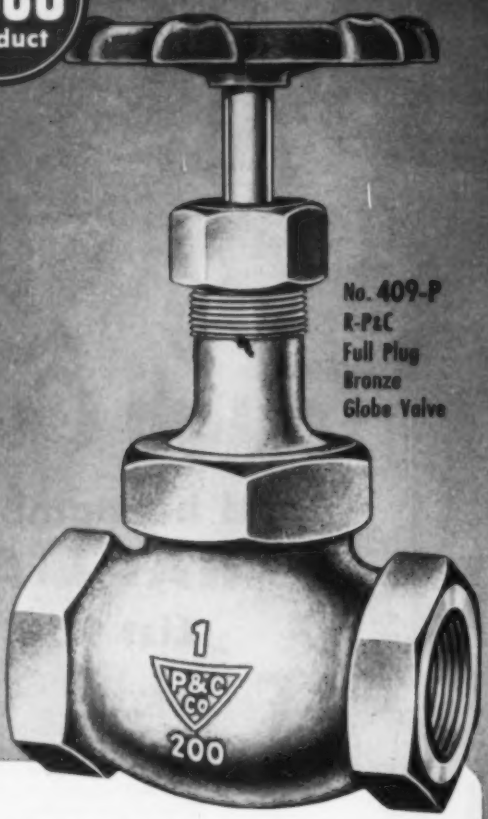

• High test bronze body and bonnet; nickel-alloy disc and seat ring; high tensile, high torque rolled bronze stem—plus large, deep stuffing box easily repacked under pressure—these are the features which make R-P&C Bronze semi-plug and full-plug Globe and Angle Valves outwear ordinary valves. They're fine for frequent or continuous throttling of steam, gas, oil, water. This type valve can be furnished in 200, 300 and 350 lb. pressures.

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R-P&C valves

The Month...

fees and travel expenses of the visiting experts, invited from all over the United States. Each lecturer was asked to provide a complete set of notes and appropriate problems which were reproduced and distributed immediately prior to each lecture.

ASTM Anniversary Meeting Breaks Attendance Records

A record-breaking number of engineers and materials men totaling 2606, official registration, were present at the 50th Anniversary meeting of the American Society for Testing Materials in New York recently. An unusually strong technical program, 165 papers in some 40 formal and informal technical sessions and 70 reports from the technical committees, commemorated the Society's formal incorporation as a national technical society in 1902.

As a result of recommendations in some 70 committee reports, at the meeting, 75 new specifications and tests were approved for publicaiton for the first time.

ACS National Meeting To Be Held In Atlantic City, N. J.

Chemical advances in fields ranging from sanitation to weed killers, which will help the world to meet the rising food needs of its ever-growing population, will be reported at the 122nd national meeting of the American Chemical Society, to be held in Atlantic City, N. J., September 14 through 19. A highlight of the meeting will be a symposium on "The Unsolved Problems of the Petroleum Industry" which will be held under the direction of Dr. W. A. Gruse of the Mellon Institute by the Division of Petroleum Chemistry.

Another highlight will be the presentation of the Society's Priestly Medal to Dr. Samuel Colville Lind of the Carbide and Carbon Chemicals Company staff at the Oak Ridge National Laboratory.

Jet Fuels Information Added To Bureau Of Mines Survey

Information on the characteristics of aviation jet fuels is included for the first time in the current national survey of aviation gasoline issued by the Bureau of Mines. The current report gives the results of analyses in company laboratories of 88 samples of aviation gasoline, produced for military use only, and the remaining 19 produced for both commercial and military use.

The report includes data on four grades of aviation gasoline and four grades of jet fuel. Tables and charts present detailed information about each sample. The samples were collected in the fall of 1951. A list of previous Bureau of Mines reports on aviation gasoline is included.

Sinclair Research Names Pinkerton Research Associate

Sinclair Research Laboratories, Inc., has named R. D. Pinkerton to the newly created post of Research Associate. Pinkerton is the former director of light oils at Sinclair Research. He started his career with Sinclair in 1930 as a part-time employee during the summer while attending the University

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Contains important and timely information on fractionating trays for distillation, absorption or liquid-liquid extraction.

It will pay you to investigate the increased efficiencies and capacities of Koch "Benturi"-type fractionating trays. Send for your copy of this new catalog.

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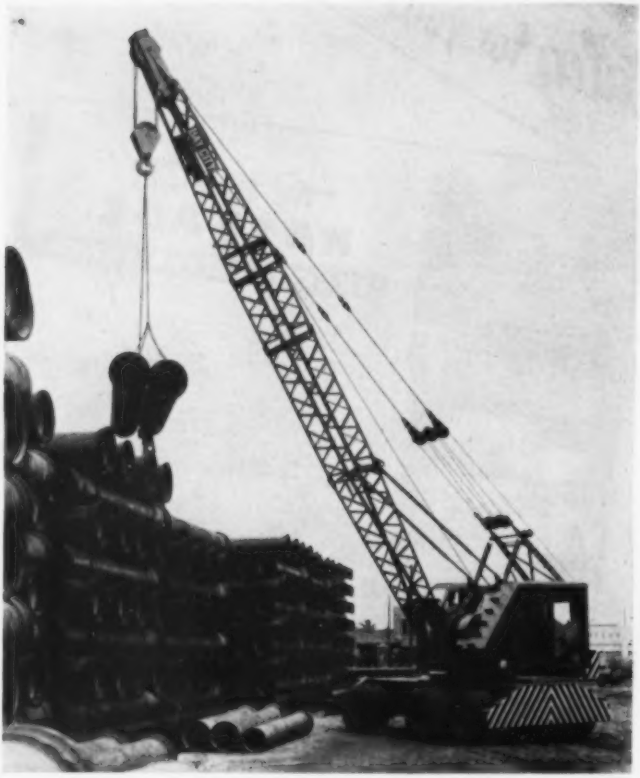

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The Month...

of Illinois. After graduation in 1932, he became a full-time employe. As Research Associate, Pinkerton will be able to devote all his time to the creation of new research projects, whereas in his former position he had to divide his time between research projects and administrative details.

Owens Named Director of New Standard-Vacuum Subsidiary

Roy M. Owens, oil refinery engineering and construction specialist, has been named managing director of a new petroleum refining subsidiary which the Standard - Vacuum Oil Company is forming in Australia to operate manufacturing facilities now undergoing expansion at an estimated cost of $30 million. Owens has a background of more than 26 years in the petroleum industry of the United States, Europe and South America. He visited Australia earlier this year as a member of a technical team which surveyed requirements for enlarging the present Altona refinery near Melbourne. Owens is a native of Texas and a 1924 engineering graduate from Texas A & M College.

Owens

Francisco Made Sinclair Technical Activities Head

C. J. Francisco has been named to a newly created post as manager in charge of technical activity for Sinclair Research Laboratories, Inc., Harvey research center. He joined the organization in 1941, following completion of his graduate training at Columbia University. Prior to his present appointment, he was director of Sinclair's Process Design Group and later Research Director of the Cracking Division at the company's new Harvey Laboratories. Francisco is the author of several patents, involving the processes for the production of better and more economical petroleum products.

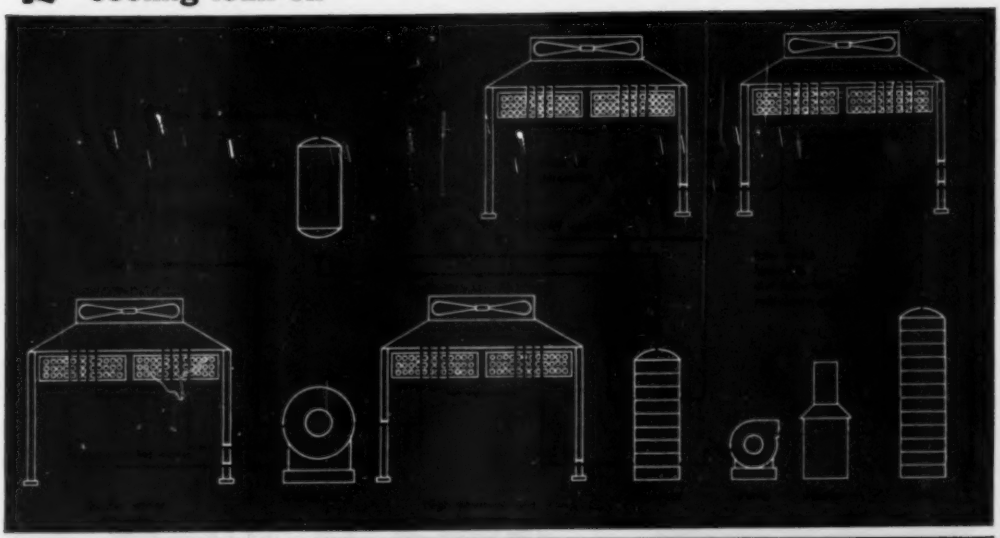
McKee Firm Names Livingston Assistant To The President

Arthur G. McKee & Company has announced the appointment of Myran J. Livingston as assistant to the president. In his new position Livingston will assist in directing the actvities of the company's petroleum refining division. For the past several years, he has been sales manager of the company's petroleum refining division and prior to that he had been in charge of the company's sales office in New York.

Ethyl Announces Large-Scale Production Of Insecticide

Plans for the large-scale production of lindane, an insecticide, have been announced by Ethyl Corporation. A new plant being built by Ethyl at Baton Rouge, La., and scheduled for completion early next year, "will make lindane

- **cooling engine jacket water**
- **cooling high pressure gas**
- **condensing overhead vapors**
- **cooling lean oil**



versatile ALCO AIRCOOLERS

ALCO Aircoolers demonstrate their versatility in natural gasoline plants. The simplified flow diagram above shows how Aircoolers are used to cool jacket water, cool high pressure gas, condense overhead vapors and cool lean oil.

The flexibility of ALCO fabricated steel header design also permits handling a number of different fluid streams in one tube bundle. For example, in some installations a single Aircooler may perform both the lean oil cooling and overhead vapor cooling functions.

ALCO Aircoolers are the logical and economical solution to all types of cooling problems where abundant good water is not available. Scale and corrosion troubles are eliminated.

For details call your nearest ALCO Sales Engineer at Beaumont, Chicago, Dunkirk, Houston, Los Angeles, New York or Tulsa.

Send Coupon for ALCO Aircooler Bulletin.

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AMERICAN LOCOMOTIVE COMPANY
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Company .....

Address .....

City ..... Zone ..... State .....

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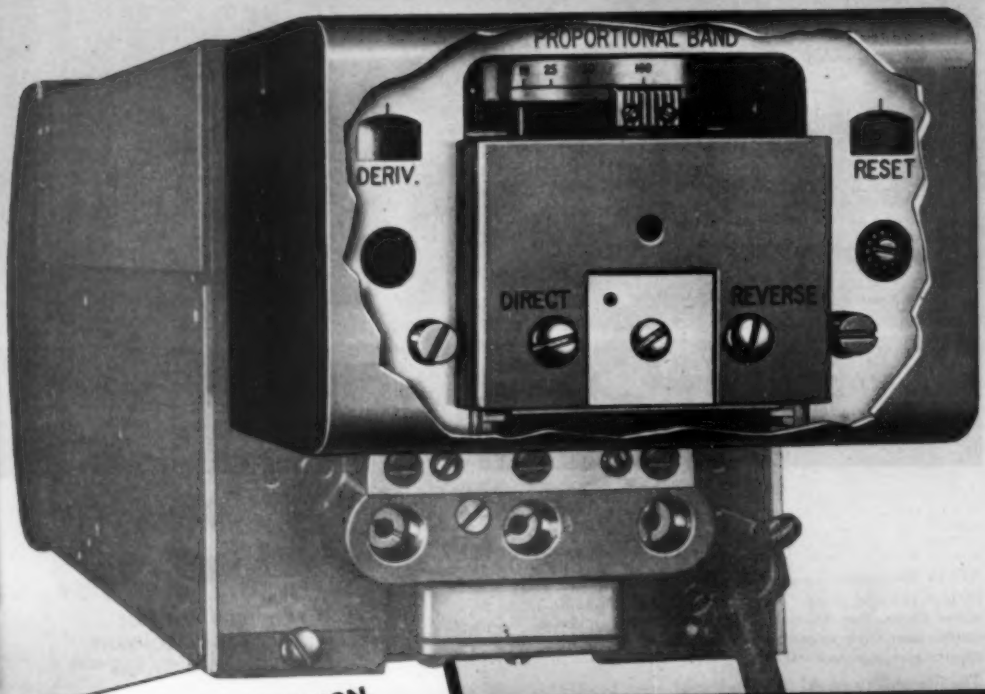
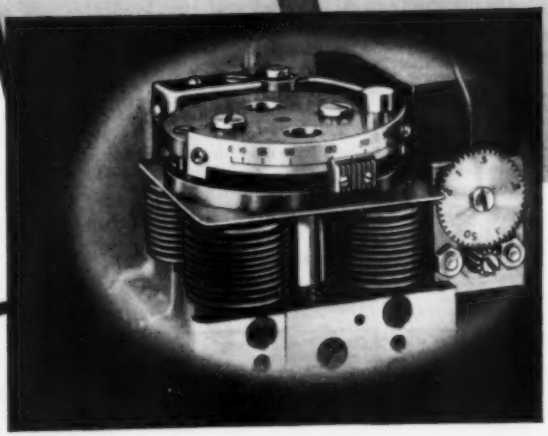
Radically new operating principle . . . Simplest Installation



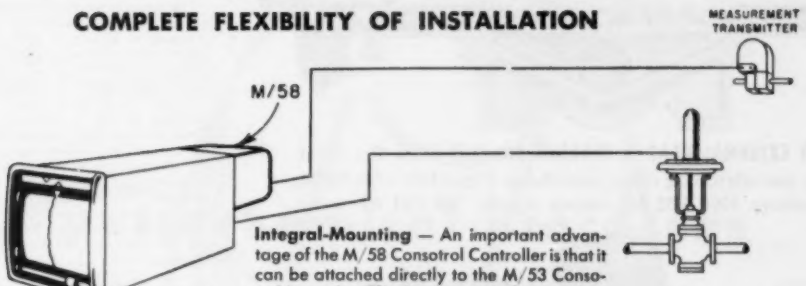
REVOLUTIONARY DESIGN

The unique "floating-disc" balancing system is shown here with dial-type reset adjustment. Derivative unit, when required, is plugged in at left of assembly. Both are readily removed or added in the field — both employ new-design adjustable restrictors providing 1000-to-1 range-ability, perfect reproducibility, and consistent rates on both increasing and decreasing air pressure. Proportional band is a lever setting, fully adjustable from 0 to infinity!

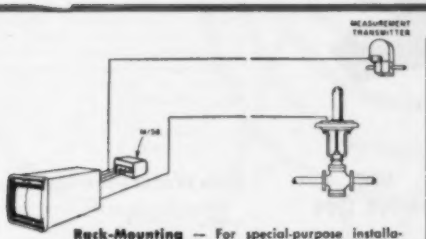


M/58 CONTROLLER

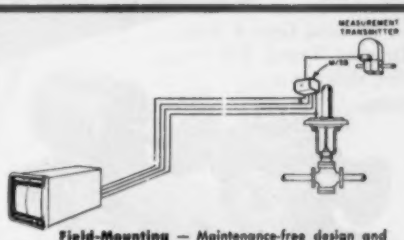
COMPLETE FLEXIBILITY OF INSTALLATION



Integral-Mounting — An important advantage of the M/58 Consotrol Controller is that it can be attached directly to the M/53 Consotrol Recorder. **Eliminates cost of mounting and of piping between panel-mounted recorder and the controller.**



Rack-Mounting — For special-purpose installations, the M/58 Controller can be rack-mounted and piped to the M/53 Consotrol Recorder or comparable unit.



Field-Mounting — Maintenance-free design and weatherproof, all-metal construction readily permit this usage when the process requires it.

Over and above its extreme compactness for graphic panel use, the new Foxboro M/58 Consotrol Controller offers unique advantages in its simplicity of design, unmatched performance, and ease of installation.

This Controller employs an exclusive, simplified balancing system in which the measurement, proportional, reset, and derivative bellows act on a single "floating-disc". With no diaphragms, only one nozzle, and only one moving part, it gives control action unrivalled in stability, sensitivity, and with positive, drift-free control point.

Installation, also, is radically simplified. The M/58 is designed to attach directly to the M/53 Consotrol Recorder (eliminating cost of piping and mounting) or, optionally, to be mounted in remote locations if required.

Write for Bulletin 463 containing full details of the M/58 Controller together with the full line of Consotrol Instruments. **The Foxboro Company, 748 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities.

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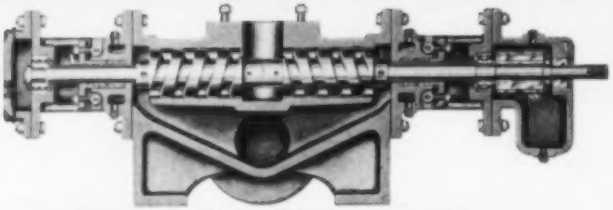
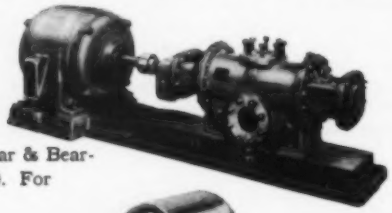
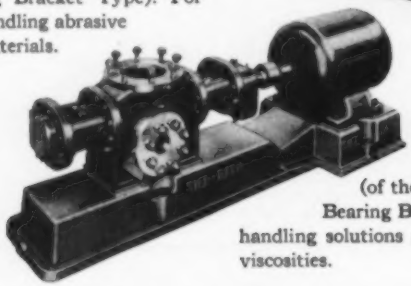


NEW EXTERNAL GEAR & BEARING BRACKET TYPE For handling non-lubricating fluids, semi-fluids. Capacities 1-700 GPM; Discharge 1000 PSI for viscous liquids, 500 PSI for water.

NEW LINER TYPE

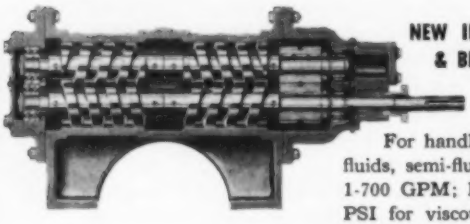
(of the External Gear & Bearing Bracket Type). For handling abrasive materials.





NEW HOPPER TYPE

(of the External Gear & Bearing Bracket Type). For handling solutions of extremely high viscosities.



NEW INTERNAL GEAR & BEARING TYPE

For handling lubricating fluids, semi-fluids. Capacities 1-700 GPM; Discharge 1000 PSI for viscous liquids, 500 PSI for light oils.

WRITE FOR NEW *"Screw Pump Reply Sheet"*

Read the front side for features and advantages—then, if you wish, fill out the reverse side for a prompt, individually-engineered recommendation!

***Sier-Bath* GEAR and PUMP CO., Inc.**

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Founded 1905 Member A.G.M.A.

Also Manufacturers of Precision Gears and Flexible Gear Couplings

The Month...

available for many crops heretofore limited to older insecticides as well as to open up broad new applications in effective pest control."

In a companion move, Ethyl announced that greatly enlarged facilities are nearing completion for the production of the insecticide, benzen hexachloride or BHC, from which lindane is derived.

Stewart Kurtz, Jr. Named Sun Technical Associate

The appointment of Stewart S. Kurtz, Jr., as technical associate in Sun Oil Company's Research and Development department has been announced by the Chemical and Engineering Division. Kurtz will move to department headquarters at Marcus Hook as a staff assistant to Dr. J. Bennett Hill. In addition to handling technical matters in his specialized fields he will represent Sun in various scientific and technical organizations outside the company.

Since 1942, Kurtz has served as manager of the company's Chemical Research laboratory at Norwood, Pa. He will be succeeded there by Dr. C. L. Thomas.

Graham, Swearingen Elected Indiana Standard Directors

David Graham and John E. Swearingen have been elected directors of Standard Oil Company (Indiana) at a special stockholders meeting. Graham is financial vice president of Standard and Swearingen is general manager of production for the company. The men fill two vacancies on the Standard board, following a stockholders vote to increase the permissible maximum number of directors from 12 to 15.

Tide Water Promotes Brook

John Brook has been promoted to special assistant to the vice president and chairman of the Eastern Division operating committee of the Tide Water Associated Oil Company. Brook started with the company in 1924 as a statistician and in 1930 was promoted to assistant to the chief statistician. He was made assistant supervisor in the statistical department in 1940, the position he held until his present promotion to the administrative department.

Standard Employe Honored For Thirty Years Service

Frederick H. Eberle, an assistant supervising engineer in the Esso Engineering department of the Standard Oil Development Company, has completed 30 years' service and was presented with his service award recently in Rahway, N. J. Eberle is a member of the American Society of Mechanical Engineers, and has been active in their Petroleum Division. He is now a member of their Refining Committee and a former member of the Executive Committee of this division.

Sinclair Names Gardner to Research Associate Post

R. H. Gardner, veteran of 33 years employment with Sinclair Oil Corporation, has been promoted to the newly

petrochemical processes

phenol
methanol
maleic and phthalic anhydride
ethylene oxide glycol ethanolamines
ammonia nitric acid ammonium nitrate urea

Foster Wheeler has been actively associated with both the petroleum and chemical industries for over 30 years and has designed and constructed many individual petrochemical process units as well as complete chemical plants.

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stable even at lower heats

SLAG...
clean, easily removed

COATING...
resists cracking down to very short stubs

SELECTION...
complete line for welding every type of stainless

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PAGE Welding Electrodes AND Rods

The Month...

created position of Research Associate. Widely known to refinery and research people, Gardner holds memberships in several organizations, among which are the Society of Automotive Engineers, and the American Society of Lubricating Engineers. The new position he has assumed is so designed to enable him to utilize all his time on research projects rather than dividing his time between research and administrative details.

U. S. Throws 'Cartel' Charge At Seven Major Oil Companies

Attorney General James P. McGranery said last month a federal grand jury in Washington will begin probing into the activities of "the international oil cartel." Both criminal and civil proceedings are being worked up by the Justice Department under the antitrust laws forbidding monopolistic practices, price fixing and restraint of trade against seven major oil companies—five American and two foreign.

McGranery listed Standard Oil of New Jersey, Standard Oil of California, The Texas Company, Socony-Vacuum Oil Company, Gulf Oil, the Royal Dutch Shell group and Anglo-Iranian Oil Company.

An official said the grand jury subpoenas will be exceedingly broad and will include everything but the "kitchen sink."

Meanwhile, Leonard J. Emmerglick, special assistant to Attorney General McGranery, was sworn in specifically to conduct the prosecution. Emmerglick conducted the government's successful antitrust suit against Aluminum Company of America six years ago.

Senator Hennings, Democrat, Mo., currently demanding a congressional investigation of the seven oil firms, said in a public statement that the group dominates United States foreign policy field in the Middle East, Indonesia and Venezuela and works together in the pricing field and elsewhere.

A spokesman for Standard of California has replied "Our record is clear" and that the international operations of its affiliated companies had been "carried on to the best interests of the United States." Eugene Holman, president of Standard of New Jersey, said his company was not a party to illegal practices of any kind.

Officials of the British-owned Anglo-Iranian Oil Company have challenged the right of American courts to take antitrust action against them, saying their firm does not operate in the United States. A spokesman for the Royal Dutch-Shell group said his company had no comment as yet, but is studying the charges.

It was learned that the Federal Trade Commission has released copies of its suppressed "cartel" report to two more Congressional groups — Senate and House Judiciary Committees. The Senate's Small Business Monopoly Subcommittee previously obtained a copy of the report and already has launched hearings on the oil "cartels."

Meanwhile, speculation continued as to what parties may be behind Hennings' persistent attack against foreign oil operations. Co-ops are being mentioned, chiefly because they have shown interest in foreign opportunities and tried to

Tenamene

the most effective additives known . . . keep gasoline cleaner . . . longer . . . at low cost

WHAT IS GUM? Gum is a non-volatile material resembling varnish or lacquer. Soluble in gasoline, gum separates only when gasoline evaporates, unless highly concentrated. Sometimes gum settles as a heavy, dark-brown oil. The enemy of engine efficiency, gum coats carburetors, plugs jets and screens, and causes valves to stick.

WHAT INHIBITORS DO. Commercial gasoline inhibitors retard oxidative deterioration, the first step in gum formation. To prevent storage loss, inhibitors should be soluble in gasoline but not in water. They should not color gasoline and should resist darkening.

THE TENAMENES — EASTMAN INHIBITORS. For years Eastman has made the most effective gum inhibitors known—Tenamene 1 and Tenamene 2. Formerly these were sold through another company under another name. Now Eastman makes them available directly and from convenient stocks. Choice between the two gum inhibitors depends on a number of factors, such as the crude, the treatment and possible caustic carryover. Tenamene 2 should be used where traces of caustic are present. Where caustic is not present, choice must be based on such tests as ASTM Gum, Oxygen Bomb or Copper-dish Gum. Since Tenamene 2 is more concentrated and non-inflammable, its slightly higher cost is frequently more than offset by lower shipping costs.

FOR MOTOR FUELS. Tenamene 1 is a mobile, tan liquid composed of 48% N-n-butyl p-aminophenol in isopropanol. 5 to 52 lbs. per 1000 bbls. inhibit gum in most motor fuels, protect dyes from fading, and retard tetraethyl lead decomposition.

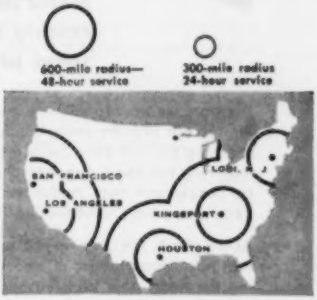
FOR MOTOR FUELS AND ALL AVIATION GASOLINES. Tenamene 2 is a mobile tan-to-red liquid comprising N,N'-di-sec-butyl p-phenylenediamine. For motor fuels generally, 2.6 to 26 lbs. per 1000 bbls. are used. Tenamene 2 has been thoroughly tested in aviation gasolines and approved for military purposes. It is highly resistant to extraction by water and caustic solutions. In hot, humid climates Tenamene 2 greatly retards deterioration of aviation gasoline that results in lead deposits. The maximum concentration allowable in aviation gasolines (8.4 lbs. per 1000 bbls.) should be added.

FOR COPPER CONTAMINATION. Tenamene 60, third member of the Tenamenes, is a mobile, red liquid composed of 80% disalicylal propylene di-imine in toluene. Traces of copper are often found in gasoline—from treating processes or from copper equipment employed during production, storage or use. Tenamene 60 overcomes the catalytic effect of copper on the oxidation stability of gasoline.

TESTS PROVE TENAMENE EFFECTIVE. Various tests with all types of gasoline proved the effectiveness of the Tenamenes. Uninhibited gasoline deteriorated rapidly in storage, forming considerable gum. Tenamene stabilized gasoline formed little gum in prolonged storage. Tennessee Eastman will be glad to make these analyses on any refiner's gasoline.

HOW TO USE TENAMENE. In general, unrefined cracked gasoline should be treated with Tenamene promptly after condensation. Refined gasoline should be treated as it is pumped to storage. If delay is necessary, add small amounts initially, the balance later. Tenamenes can be added in concentration, but are better added as dilute stock solutions since small quantities are generally involved. Common procedures are the proportioning pump, eductor or gas-pressure method. Tenamene 1 and 2 should be protected from air to prevent discoloration. Tenamene 60, however, does not need inert atmosphere for application.

WHERE CAN YOU GET TENAMENE? Eastman can give top service on your requirements of these excellent additives. Stocks of Tenamene are carried at five convenient locations. A glance at the map below shows delivery schedules. Write to one of our sales representatives* or to Kingsport, Tennessee for prices, specifications, and other information.



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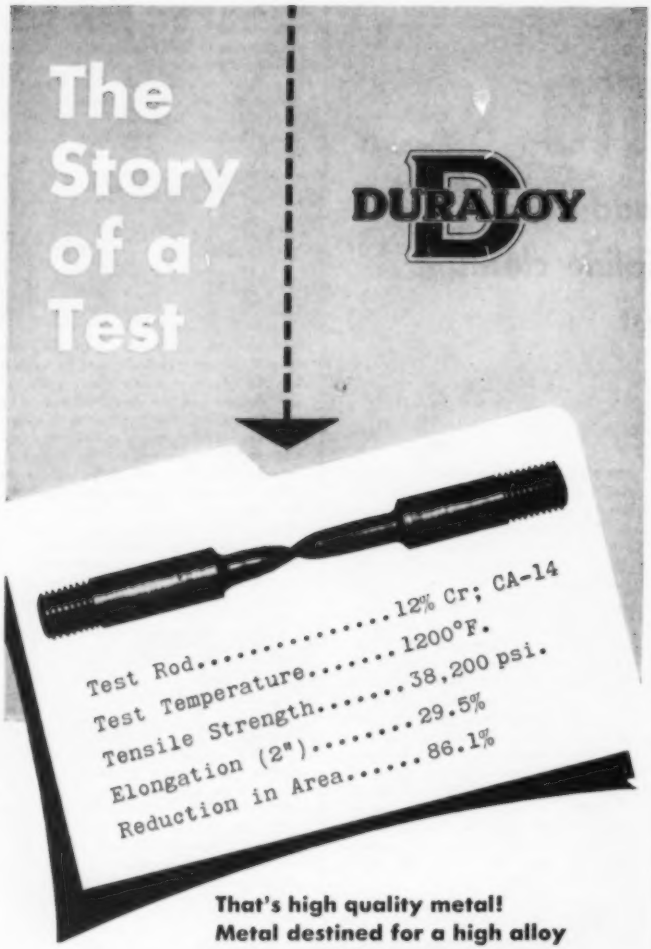
SALES REPRESENTATIVES: New York—260 Madison Ave.; Framingham, Mass.—7 Hollis St.; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; St. Louis—Continental Bldg.; Houston—412 Main St. **West Coast: Wilson Meyer Co.,** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth Ave.; Seattle—821 Second Ave.



That's high quality metal! Metal destined for a high alloy casting which has to meet some pretty rigid specifications!

The story we want to tell here is about our Testing Facilities. We have right in our foundry every conceivable testing facility needed when checking static or centrifugal high alloy castings for industry. Where required, we make complete chemical, metallurgical, and mechanical checks and tests. And have both a 400,000 volt X-ray unit and gamma-ray unit, for checking the final casting for hidden flaws.

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The Month...

move into Iran when Anglo-Iranian Oil Company was tossed out. They also were behind the Cannon Resolution of 1950 which never got going but which would have called for an investigation of the entire oil industry.

Transfers and Changes Are Listed by Socony-Vacuum

Vernon Loyd, in charge of maintenance at Socony-Vacuum's East Chicago, Ind., refinery, has been transferred to the Refinery Engineering Division as senior engineer in the maintenance section. Robert J. Tummons has been promoted to head of the operating group, and William G. Hard has become Tummon's assistant. Urban H. Wagner, senior process engineer, has joined Standard-Vacuum as assistant chief process engineer in the refining coordination department in New York.

James P. Shambaugh, head of the process promotion section, has been transferred to the process promotion section of the research and development department, in New York, to assist A. V. Danner in handling licensing activities. P. J. Wolfe, assistant head of the economics evaluation section, has been promoted to head of the process promotion section, and D. A. Hermanson has taken over Wolfe's duties in the economics evaluation section.

J. W. Smith to Head Conoco Refinery at Glenrock, Wyo.

J. W. Smith has been promoted to superintendent of Continental Oil Company's refinery at Glenrock, Wyo. Former assistant superintendent of Conoco's refinery at Denver, Colo., he succeeds the late Paul L. Rawdon, who died June 17.

R. W. Broadhurst, former resident engineer at Ponca City, will succeed Smith.

Smith has had nearly 30 years of experience in refinery operations and has been with Conoco since 1923. Broadhurst joined Continental in 1941.

Two Gulf Companies Name Huggins Vice President

R. Paul Huggins, heretofore vice president of Western Gulf Oil Company in charge of California operations, has been elected a vice president of Gulf Oil Corporation and of Gulf Refining Company.

As of September 15, 1952, he will reside in Houston and take charge of the crude oil purchasing activities of the two companies under general supervision of J. H. Russell, vice president in charge of pipe lines and crude oil purchasing.

T. H. Wallace, heretofore assistant to Huggins, will succeed him as vice president in charge of Western Gulf Oil Company, with offices in Los Angeles.

SoVac Employes Awarded $3500 Suggestion Prize

Joseph W. Darby and John Moran, operators at the Paulsboro, N.J., refinery of Socony-Vacuum Oil Company, Inc., were jointly awarded $3500 recently under the company's suggestion system. The award, to be divided equally, is the largest ever made by the company for a single suggestion. The suggestion, submitted separately by each of the two

Have a Part to Produce From Tubing?

PACIFIC PRODUCES THE TUBE!

Sizes and Analyses

TUBING
SEAMLESS CARBON
MT—1015, 1020, 1025
Round: 3/16" to 2¾" O.D.
Square: ¼" to 2" O.D.
SEAMLESS ALLOY
4130—NE 8630
Round: 3/16" O.D. to 3¾" O.D.
Square: ¼" to 2" O.D.
CHROME
4%-6%,
6%-8%,
8%-10%
3/16" to 1⅞" O.D.
STAINLESS STEEL
Seamless and Welded
Types 304, 316, 321, 347.
Round: ¼" to 2⅞" O.D.
Square: ¼" to 1⅞" O.D.
WELDED CARBON TUBING
⅜" to 3" O.D.

BARS
C-1018, B1113
COLD FINISHED
3/16" to 2½"
For Other Shapes, Contact Mill.

If you are fabricating tubing into finished parts . . . manufacturing small parts that require piercing before forming or machining . . . if your process or product requires a conductor for fluids, or strong, light-weight structural parts . . . you can profit by calling Pacific Tube Company. We can serve you quickly and economically.

Pacific has the modern tube mill and the facilities for the *quality* production of tubes, rods and bars in a wide range of sizes and analyses. All of Pacific's production is drawn and finished to suit the most exacting specifications for dimension, analysis and finish. In addition, we may be able to help you solve tubing problems with assistance in metallurgy, engineering or design.

Get more information about Pacific Tube Company products and service today. Clip and mail the coupon for our newest Tubing Bulletin or to have a representative call. No obligation, of course.

West Coast Distributors for:

Superior Tube Company, manufacturers of fine small tubing in all analyses from .010" to ⅝" O.D. and in certain analyses (.035" max. wall) up to 1⅜" O.D.

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First Steel Tube Mill in the West

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☐ Please rush me your new Tubing Bulletin.
☐ Have your representative call.

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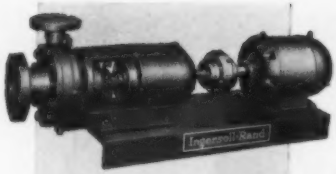
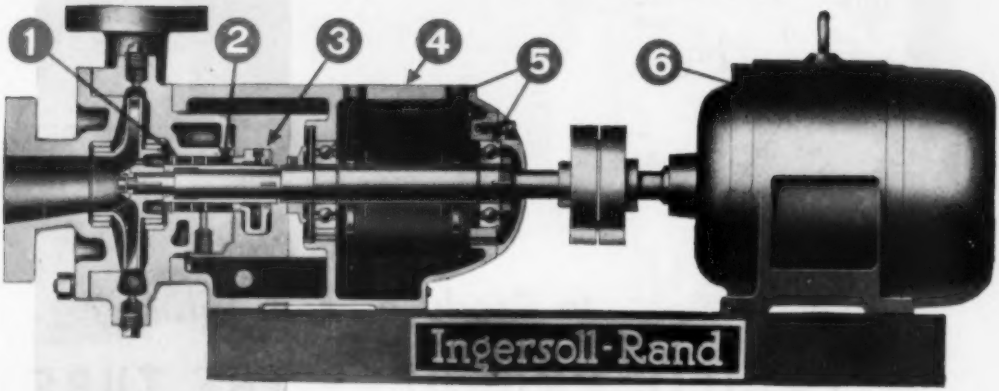
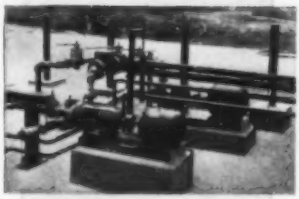


WORTH LOOKING INTO

The Ingersoll-Rand, Class CRVR, Cradle-Mounted Centrifugal Pumps





Developed Especially for Process and Refinery Service — to assure easier maintenance and less of it!

Most centrifugal pumps *look* pretty much alike — on the outside. But it's what's *inside* and who builds them that makes the big difference in performance, dependability and maintenance. Note, for example, these features of the new Ingersoll-Rand Class CRVR pumps:

1. **DEEP, WATER-COOLED STUFFING BOX**—with ample space for either conventional ring packing or the Cameron mechanical shaft seal.
2. **HOOK-TYPE SHAFT SLEEVE** — sealed at impeller end and free to expand toward gland end. Eliminates leakage under sleeve and assures a tight impeller assembly.
3. **SPLIT-TYPE SMOTHERING GLAND** — traps any shaft seepage of volatile or hazardous liquids. Gland is quickly removed for access to stuffing box.
4. **HEAVY, BARREL-TYPE CRADLE** — for giving extra-firm support to shaft and bearing assembly. Large side openings simplify inspection and packing.
5. **HEAVY-DUTY BALL BEARINGS** — of the single-row, deep-groove type, with efficient and dependable ring oil lubrication.
6. **DRIVE MOTOR OF ANY DESIRED TYPE** — drip-proof, splash-proof, totally-enclosed, or explosion-proof. Heat from pump shaft is completely isolated from motor.

You'll discover many other important features, too, — features that make Ingersoll-Rand's completely new line of Cradle-mounted Centrifugal Pumps ideally suited to the petroleum and other process industries. These units are available for capacities to 550 gallons per minute and heads up to 250 feet. Your nearest I-R representative will be glad to give you the complete story

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award winners, brought about a reduction in shut-down time and in loss of solvent used by the Paulsboro refinery's Duo Sol unit which processes high-grade lubricating oils.

NGAA Schedules Regionals In Texas On 1952 Calendar

Two regional meetings have been announced by the Natural Gasoline Association of America for the remaining 1952 calendar year. On October 24, the meeting place is the Blackstone Hotel, Tyler, Texas; and on November 21, a meeting will be held at the Herring Hotel, Amarillo, Texas.

NGAA Tulsa headquarters have announced the annual convention will be held April 29-May 1, 1953, at the Rice Hotel, Houston.

Dow Appoints J. M. Parish Chief Engineer at Freeport

Recently appointed chief engineer of the Texas division of the Dow Chemical Company, J. M. Parrish will be responsible for the operations of the engineering department. Parish has been a Dow employe since 1940 when he graduated from Texas A. and M. College with a degree in mechanical engineering. Joining Dow at Midland, Mich., where he served as student engineer, Parish was later transferred to Freeport, Texas.

He had served as superintendent of the construction and maintenance control department at Freeport for the past two years.

Synthetic Fuels Cost Report Analyzed by National Council

The National Petroleum Council's Committee on Synthetic Liquid Fuels Production Costs last month presented its analysis of the Ebasco Services, Inc., report prepared for the Bureau of Mines, analyzing Bureau hydrogenation cost figures.

The Council says that statements circulated in April misled the public into believing that Ebasco concluded that industry could finance, build, and operate a coal hydrogenation plant which could give the motorist a synthetic gasoline equal to today's motor fuel in quality and competitive with the present cost at the refinery of about 12 cents per gallon.

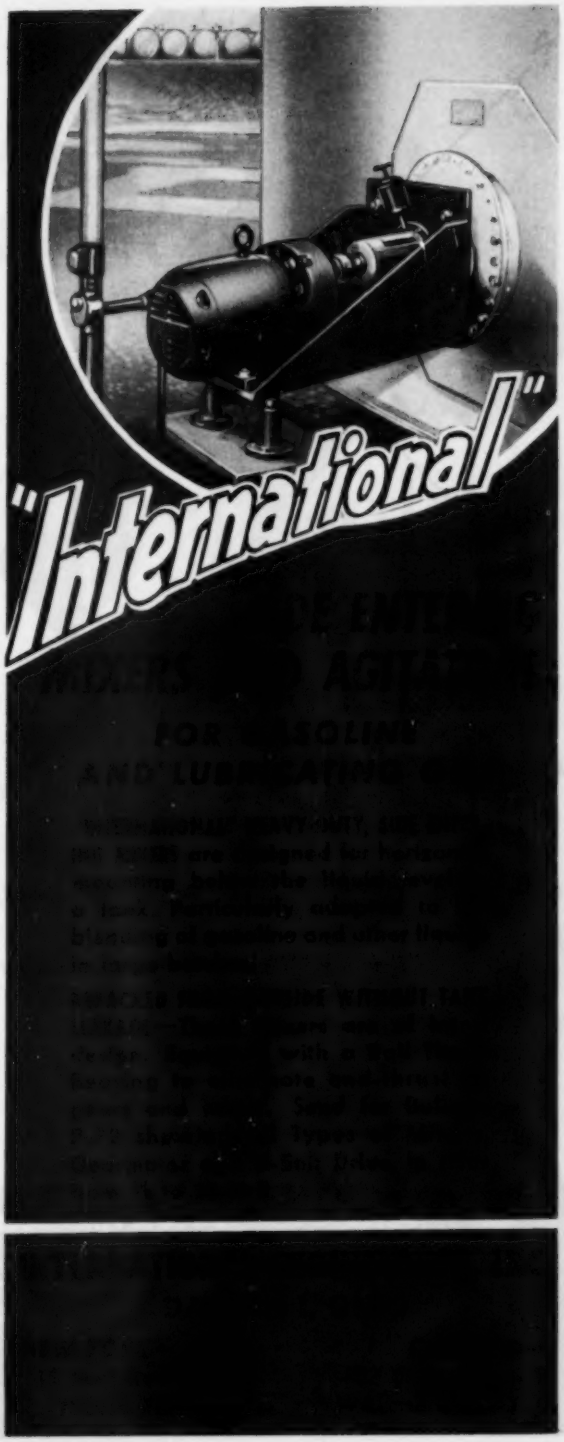
To the contrary, the Council pointed out today, the Ebasco report in its principal economic conclusion said:

"We do not believe it would be feasible to finance the projects described in the Bureau of Mines Report dated October 25, 1951, with private capital under conditions prevailing at January 1, 1951."

The Council says Ebasco pointed out that to make the venture attractive, a return of about 15 percent after taxes should be realized. This would result in a gasoline cost of 28 cents per gallon, even allowing for the sale of chemicals.

The Council's half-million dollar survey of synthetic liquid fuels costs placed the actual manufacturing cost at 41 cents per gallon.

Oil men are talking about a true synthetic fuels plant—not a plant where synthetic fuels are a by-product of a chemicals operation, the Council explained. It is largely on this point that



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The Month...

the Council and the Bureau of Mines differ.

Construction Work Starts On Texas Gasoline Plant

Reef Fields Gasoline Corporation of Houston and Skelly Oil Company, Tulsa, have started construction work on a natural gasoline plant in northeastern Howard County, West Texas, which will have a capacity of 200,000 gallons daily. Gathering lines from several fields are also being constructed and in excess of 35 million cubic feet natural gas daily will be processed. Delta Engineering Corporation, Houston, is contractor on the gasoline plant.

W. R. Burns Joins Catalytic As Senior Project Engineer

T. Ellwood Webster, president of Catalytic Construction Company, has announced that Weldon Riley Burns has joined the company's refining division as senior project engineer. Burns is a graduate of the University of Oklahoma with a B. S. degree in petroleum. Prior to his present position, he was with the Badger Process Division of Stone and Webster Engineering Corporation where he served as a project engineer.

Before his association with Badger in 1946, he had been plant superintendent for Northwestern refining company.

Lammot du Pont, 71-Year-Old Industrialist, Dies

Lammot du Pont, for 22 years the guiding hand of the E. I. du Pont de Nemours & Company, Inc., died recently of heart disease. The 71-year-old industrialist, who participated in the development of the atom bomb, helped supply America's armed forces with munitions in World War II, and sponsored the development of nylon, died in a hospital in New London, Conn., after about one month's illness. He was the eighth member of his family and the third brother in succession to head the chemical company founded by his great grandfather. He served as president of the company from 1926 to 1940, and as chairman of the board from 1940 to 1948.

Timken Roller Executive, R. C. Brower, Dies In N. H.

R. C. Brower, secretary-treasurer and director of The Timken Roller Bearing Company, died at his summer home at Melvin Village, N. H., recently. He was 60 years of age. Brower first entered the bearing business in 1916 when he was hired as sales manager for the Bearing Service Company. He joined The Timken Roller Bearing Company in 1923.

Walter Schulze Dies

Walter A. Schulze, member of the research planning board of Phillips Petroleum Company, Bartlesville, Okla., died July 30 in Bartlesville. He was 52 years old and had been with Phillips since 1929. He held more than 200 patents and many of his processes are in use throughout the industry. The company announced that a memorial fund had been established with R. C. Alden as trustee.

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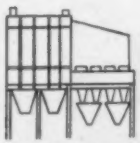

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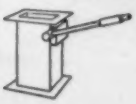

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- ☐ TDC-148 B&W Croloy Stainless Steels, Condensed Data on Working Seamless or Welded Tubing and Pipe
- ☐ TA-1517 B&W Stainless Steel Tubing for the Food Processing Industry
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- ☐ TB-12 B&W Alloy Tubes and Pipe, Condensed Technical Data on High-Temperature Steels
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- ☐ TB-329 B&W Heat Exchanger and Condenser Tubes, Seamless and Welded, Stainless, Alloy and Carbon Steels
- ☐ TB-344 Applications of B&W Tubular Products — Stainless, Alloy and Carbon Steel, Seamless and Welded
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- ☐ TDC-138 B&W Pipe, Seamless and Welded, Carbon, Alloy and Stainless Steels, Dimensions, Weights, Specifications, Grades, Analyses
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BOOKS of Current Interest

Review and Comment for the Process Man

Temperature Measurements, Control

The Measurement And Control of Temperatures In Industry, R. Royds, Chemical Publishing Company, 212 Fifth Avenue, New York, N. Y., $5.

The latest developments in temperature measurement and control to help the metal, chemical, petroleum, glass and refractory, cement, varnish, rubber, textile and related industries in maintaining the highest possible thermal efficiency is the theme of this volume.

The various methods and equipment which are available for the measurement of temperatures in each particular range are discussed. Much space is devoted to the standardization and automatic control of temperatures in industry. Attention is given to improving the quality and reliability of industrial products, an increased rate of production, and the saving of fuel and labor by the application of automatic temperature controls. Numerous illustrations, graphs, tables and equations are included.

Micelle Formation Range

Critical Range for Micelle Formation by an Oil-Dispersible Soap in a Hydrocarbon Solvent, U. S. Naval Research Laboratory, Available from Office of Technical Services U. S. Department of Commerce, Washington 25, D. C., 50 cents, Code No.: PB 106733.

In moist benzene, micelle formation by the oil-dispersible soap, calcium xenylstearate, has been studied. A treatment is presented for the interpretation of flourescence depolarization data obtained from a system in which the emitting dye is present partly as a component of soap micelles and partly in true molecular solution. The data obtained are consistent with a simple mass-law equilibrium between molecularly dissolved and micellar soap. A knowledge of this equilibrium provides guidance in the development of improved rust-inhibiting oils.

Aircraft System Fires

Investigation of Fires Originating In Aircraft Vacuum Systems, U. S. Civil Aeronautics Administration, available from the Library of Congress, Photoduplication Section, Washington 25, D. C., Microfilm $1.75, Photostat $2.50, Code No. of Report: PB 106754.

A simple bench test was developed to duplicate the internal fire conditions, but without destroying a vacuum pump in each investigation. Various vacuum piping systems, including systems in use and those proposed for future use, were compared to determine the relative abilities of the systems to withstand internal fires. Tests conducted led to the development of a means for preventing internal vacuum system fires.

Fog Foam Studies

Fog Foam Studies, U. S. Army Corps of Engineers, available from the Library of Congress, Photoduplication Section, Washington 25, D. C. Microfilm $4.25, Photostat $12.50, Code No. of Report: PB 106708.

Tests were performed to determine the effect of hydraulic pressure on the fire extinguishing characteristics of fog foam. Moreover, standards of performance for fog foam nozzles were established experimentally.

Taylor Instrument Releases Instrumentation Color Film

"Information At Work" is the title of a 30-minute full-color film on instruments put out by Taylor Instrument Companies, tracing the development of instruments from those which do a relatively simple job to today's products used to indicate, record and control the most complex processes. The film may be booked without charge through the company's Public Relations Department at Rochester, N. Y.

Engineering Handbook

Handbook of Engineering Fundamentals, Edited by Ovid W. Eshback, Second Edition, John Wiley & Sons, New York, N. Y., $10.

The first edition of the **Handbook of Engineering Fundamentals** was a departure from traditional publication of material of this nature. In addition to serving a utilitarian purpose in an economical way, it attempted to bring together the most important basic facts and principles upon which our technological and engineering advancement depends. The object of the book has not been changed, but new knowledge, change of emphasis and methods of presentation have brought about a review and revision. Some of the changes incorporated in this second edition include:

The engineering tables have been enlarged to include standard structural sizes for aluminum, and data on tangents and offsets for the use of civil engineers. The treatment of mathematics has been considerable revised. Some of the simple and commonly known items previously introduced for completeness have been eliminated, and greater stress has been placed on statistics, determinants and vector analysis. The section on electricity and magnetism has been completely revised, the theory being presented in the MKS system of units. The last section on engineering law has also been rewritten.

Fats, Oils, Waxes, Acids

Properties of the Principal Fats, Fatty Oils, Waxes, Fatty Acids and Their Salts, M. P. Doss, The Texas Company, 135 E. 42nd Street, $5.

The author of this new book, M. P. Doss, Technical Librarian of The Texas Company, previously published a compilation—"The Physical Constants of the Principal Hydrocarbons"—which was adopted by the Technical Advisory Committee of the Petroleum Administration for War as its official standard during World War II.

The new book should be of considerable interest to the fatty oil, petroleum, and chemical industries, and especially to manufacturers of lubricants. It covers the properties of approximately 50 of the principal fats, fatty oils, and waxes. Doss surveys only aliphatic acids, but he tabulates the properties of more than 800 of these. The unique part of the book is the data given on the salts of the fatty acids ranging from aluminum through zirconium. Approximately 1750 salts are listed. This material has never previously been brought together and it includes considerable unpublished data.

Residual Fuels Properties

Properties of Residual Petroleum Fuels. I. Reduction of the Vanadium Content by Solvent Precipitation, National Research Council of Canada, available from the Library of Congress, Photoduplication Section, Washington 25, D. C., Microfilm $1.75, Photostat $2.50. Code No. of report: PB 106659.

The removal of vanadium from residual petroleum fuels by asphaltene precipitation has been studied. Comparative precipitations showed that the amount of vanadium removed is generally proportional to the amount of asphaltene precipitated by the solvent.

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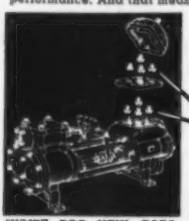

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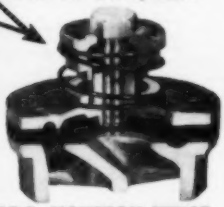

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American Locomotive Co. 135
(A4) Allis-Chalmers Manufacturing Co. 19
(A5) Alloy Steel Products Co. 42
(A6) Aluminum Company of America 165
(A7) American Meter Co. 2
(A8) Armstrong Cork Co. 60
(A9) Armstrong Machine Works 36-37
(B1) Askania Regulator Co. 215

B

(B2) The Babcock & Wilcox Co. 28-29
(B3) The Babcock & Wilcox Co.
Tubular Products Division 148-149
(B4) The Babcock & Wilcox Co. 53
(B5) Badger Manufacturing Co. 164
(B6) Bailey Meter Co. 206
(B7) Baldwin-Hill Co. 212
(B8) Baroid Sales Division
National Lead Co. 202
(B9) The J. B. Beaird Co. 40
(C1) Beaver Pipe Tools, Inc. 189
(C2) Big Three Welding Equipment Co. 25
(C3) Big Three Welding Equipment Co. 189
(C4) Black, Sivalls & Bryson, Inc. 30
(C5) Blaw-Knox Co. 160
(C6) Blaw-Knox Co. 183
(C7) Bridgeport Brass Co. 197
(C8) The Bristol Co. 17
(C9) Brown & Root, Inc. 63
(D1) Buell Engineering Co. 147
(D2) Byron Jackson Co. 127

C

(D3) Carrier Corp. ..... Opp. 189
(D4) Cast Iron Pipe Research Assoc. 210
(D5) Catawissa Valve & Fittings Co. 177
(D6) The Chapman Valve Mfg. Co. 131
(D7) Chemical Construction Corp. 129
(D8) Chicago-Wilcox Mfg. Co. 196
(D9) Childers Manufacturing Co. 26
(E1) Clark Bros. Co. 171
(E2) The Clark Manufacturing Co. 130
(E3) Condenser Service & Engr. Co. 215
(E4) Corning Glass Works 200
(E5) Crane Company 123
(E6) Croll-Reynolds Co. 210

D

(E7) The Davison Chemical Corp. ..... Opp. 121
(E8) S. D. Day Co. 215
(E9) Dean Brothers Pumps Inc. 169
(F1) Dempster Brothers, Inc. 33
(F2) E. I. du Pont de Nemours & Co. 46
(F3) E. I. du Pont de Nemours & Co. 151
(F4) E. I. du Pont de Nemours &
Co. ..... Insert 156-157
(F5) The Duraloy Co. 142

E

(F6) The Eagle-Picher Co. 14-15
(F7) Electric Steel Foundry 5
(F8) Elliott Co. 119
(F9) Enjay Company, Inc. 172

F

(G1) Fischer & Porter Co. 35
(G2) Fisher Governor Co. 198
(G3) The Fluor Corp. 191
(G4) Foster Wheeler Corp. 139
(G5) The Foxboro Co. 136-137

G

(G6) General Chemical Division
Allied Chemical & Dye Corp. 158
(G7) General Electric Co. 10-11
(G8) A. P. Green Fire Brick Co. 214
(G9) Grinnell Company, Inc. 44
(H1) The Griscom-Russell Co. 178
(H2) Gunite Concrete & Construction Co. 199

H

(H3) Hills-McCanna Co. 209

I

(H4) Industrial Pyrometer Co. 177
(H5) Ingersoll-Rand Co. 144
(H6) Instruments, Inc. 196
(H7) International Engineering, Inc. 145
(H8) The International Nickel Co. 220

J

(H9) The C. O. Jelliff Mfg. Corp. 192
(J1) Johns-Manville Corp. 24

K

(J2) Kaylo Division
Owens-Illinois Glass Co. 168
(J3) Keasbey & Mattison Co. 39
(J4) The M. W. Kellogg Co. 20-21
(J5) The C. M. Kemp Mfg. Co. 126
(J6) Kerrigan Iron Works, Inc. 181
(J7) Koch Engineering Co. 133

L

(J8) Ladish Co. ..... Opp. 188
(J9) Layne & Bowler, Inc. 32
(K1) Lee Construction Co. 173
(K2) Leeds & Northrup Co. 8
(K3) Warner Lewis Co. 173
(K4) The Lummus Co. 9

M

(K5) Manning, Maxwell & Moore, Inc. 38
(K6) The Master Electric Co. 182
(K7) A. Y. McDonald Mfg. Co. ..... IV Cover
(K8) Arthur G. McKee & Co. 125
(K9) Metal Goods Corp. 64
(L1) The Midvale Co. 154
(L2) Minneapolis-Honeywell Regulator Co. 195
(L3) Mixing Equipment Co. 48
(L4) Murray Iron Works Co. 187

N

(L5) National Carbon Co. 162
(L6) W. H. Nicholson & Co. 183

O

(L7) Oakite Products, Inc. 212
(L8) Oil Well Supply Division
United States Steel Co. 59
(L9) Orbit Valve Co. 56

P

(M1) Pacific Tube Co. 143
(M2) Page Steel & Wire Division
American Chain & Cable Co. 140
(M3) Peerless Pump Division
Food Machinery & Chemical Corp. 31
(M4) Penberthy Injector Co. 216
(M5) Perco Division
Phillips Petroleum Co. 176
(M6) Petro-Chem Development Co. 146
(M7) Petrolite Corp. 41
(M8) Pittsburgh Lectrodryer Corp. 43
(M9) The Wm. Powell Co. 184
(N1) The Pressed Steel Co. 211

R

(N2) Reading-Pratt & Cady Division
American Chain & Cable Co. 132
(N3) The Refinery Engineering Co. 167
(N4) Refinery Supply Co. 185
(N5) Republic Steel Corp. 18
(N6) Republic Steel Corp. 193
(N7) Revere Copper & Brass Inc. 219
(N8) The Ric-Wil Co. 190
(N9) The Ridge Tool Co. 128
(P1) Rochester Manufacturing Co. 175
(P2) Rockwell Manufacturing Co. ..... Insert 64-65
(P3) Rockwood Sprinkler Co. 3
(P4) Roots-Connersville Blower Corp. 45

S

(P5) Shand & Jurs Co. 22
(P6) Shell Oil Co. 208
(P7) Sier-Bath Gear & Pump Co. 138
(P8) Sims Pump Valve Co., Inc. 150
(P9) Six Wheels, Inc. 134
(Q1) The Edward Soph Co. 209
(Q2) Stone & Webster Engr. Corp. ..... Opp. 120
(Q3) Sun Shipbuilding & Dry Dock Co. 204
(Q4) Superior Manufacturing Co. 192

T

(Q5) Tennessee Eastman Co. 141
(Q6) The Terry Steam Turbine Co. 207
(Q7) Texas Pipe Bending Co. 23
(Q8) The Timken Roller Bearing Co. 4
(Q9) The Titusville Iron Works Co. 16

U

(R1) Union Asbestos & Rubber Co. 54
(R2) United States Gasket Co. 166

V

(R3) Henry Vogt Machine Co. 205

W

(R4) W-K-M Company, Inc. 194
(R5) Walworth Co. 174
(R6) Warren Petroleum Corp. ..... I Cover
(R7) Watson-Stillman Co. 180
(R8) Whiton Machine Co. 175
(R9) Wolverine Tube Division
Calumet & Hecla Consolidated
Copper Co. 186
(S1) Worthington Corp. 6
(S2) Worthington Corp. 7
(S3) Wyatt Metal & Boiler Works ..... III Cover

Y

(S4) Yarnall-Waring Co. ..... II Cover

Z

(S5) Zallea Brothers 27

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New Catalogs AND EQUIPMENT LITERATURE

For copies of the catalogs and new equipment literature listed, use one of the convenient Reader Service Postcards on this page. Just circle the number on the card corresponding to the number of the item in which you are interested.

Tube Exchanger Bulletin

The Griscom-Russell Company has published a bulletin on a finned tube heat exchanger with applications for heating and cooling liquids and gases, and for condensing vapors. Complete construction details, specifications, dimensions and installation arrangements of these standard interchangeable units are also included.

Circle No. 1 on Postcard

Heater, Pumping Booster

A bulletin featuring the "Deuce"—a combination tank car heater and pumping booster, has been issued by the Cleaver-Brooks Company. With the "Deuce," the bulletin says, it is possible to raise penetration asphalts, tars and other materials to the required high application temperatures, and deliver the material from the tank car to distributor, transfer truck or storage tank. The unit heats and transfers material through the direct oil fired pumping booster.

Circle No. 2 on Postcard

Pump Applications Guide

A new type of reference chart on small pump applications has been developed by Tuthill Pump Company. In one convenient table, this guide lists the various types of Tuthill pumps, the services for which each is built, the performance characteristics, types of packing, styles of mounting, and features that distinguish each model.

Circle No. 3 on Postcard

Rubber Products Catalog

The Goodyear Tire & Rubber Company has issued a new catalog, "Rubber Products for the Oil Producer and the Oil Refiner," which is designed to aid the oil man in choosing the proper types of materials to secure greatest service at lowest cost. Every product described in the catalog has its own application and is specifically engineered for an individual job or operation.

Circle No. 4 on Postcard

Pressure Gauges

Two new data sheets have been published by Minneapolis-Honeywell Regulator Company on pressure gauges. Specification Sheet 708 describes Brown Indicating and Recording Pressure Gauges. Construction and engineering details are included.

Specification Sheet 710 describes Brown Indicating Recording Pressure Gauges with pneumatic control.

Circle No. 5 on Postcard

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MAIL IT NOW . . . *CARD EXPIRES NOVEMBER 10, 1952

New Catalogs AND EQUIPMENT LITERATURE

Use one of the free and convenient Reader Service Postcards on this page to request copies of the catalogs in which you are interested.

Metallic-Plastic Packing

The Durametallic "Handy-Pack" package of general purpose packing is described in a new bulletin published by the Durametallic Corporation. The bulletin explains that the "Handy Pack" package consists of a convenient combination of Durametallic and Dura Plastic spiral packings ready for cutting into stuffing box rings. The bulletin states that "Handy-Pack" provides flexible, lubricated metallic and semi-metallic spirals for meeting average stuffing box requirements.

Circle No. 6 on Postcard

Electronic Flow Meter

Instrumentation Data Sheet 10.3-5, published by the Minneapolis-Honeywell Regulator Company, describes the Potter-Brown Flowmeter for measurement of fluids over a wide range of temperatures and pressures with an accuracy of one-half percent. The new system is easily installed, has linear characteristics, and can be used to measure, record and control flow at one or more points.

Circle No. 7 on Postcard

Heat Exchangers Catalog

Designed to meet the widest possible range of application for heating, cooling, condensing, and evaporating, the basic types of Superior Combustion Industries, Inc.'s heat exchangers are described in a new catalog released by the company. The basic types illustrated in the catalog "may be considered standard" but their design is readily adaptable to whatever variations may be required, the company says. It presents the basic components—heads, shells, and tube bundles—in a manner which simplifies selection and specification.

Circle No. 8 on Postcard

Braided Rod Packings

A bulletin outlining the advantages of Lattice-Braid rod packing has just been issued by The Garlock Packing Company. The bulletin contains sectional drawings showing the unique structure of Lattice-Braid Packings, descriptions of different types, tables showing general service recommendations and specifications.

Circle No. 9 on Postcard

Aluminum Tube Fittings

Hydraulic and other fluid-handling applications where the economy and efficiency of aluminum tubed systems can be used to advantage are described in bulletin 4316B2 of The Parker Appliance Company, which also presents the 12 Parker aluminum Triple-lok tube fitting shapes now available from standard stock.

Circle No. 10 on Postcard

Catalyst Brochure

A new brochure on catalysts, including the history and uses as well as manufacturing methods, has been published by The Harshaw Chemical Company. The brochure outlines Harshaw's line of catalysts and presents details on how the company can develop and prepare special catalysts for individual users.

Circle No. 11 on Postcard

(More Literature Items on Pages 153, 155, 156, 157, 159)

PETROLEUM REFINER Reader Service Postcard—August, 1952, Issue*

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D	B4	C4	D4	E4	F4	G4	H4	J4	K4	L4	M4	N4	P4	Q4	R4	S4	T4
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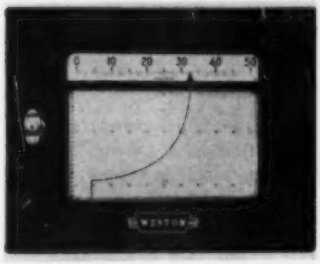
NEW EQUIPMENT and Manufacturers' Literature

KEEP INFORMED by requesting additional information on new equipment and services described here. SAVE TIME by using the Reader Service Postcards on opposite page. Circle number on card corresponding to the number listed at the end of each new equipment item on which you desire additional information.

Recording Potentiometer



A new recorder of the null-balancing (potentiometer) type, claimed to set new standards for both mechanical and electrical design simplicity and to provide many operating advantages, has been announced by the Weston Electrical Instrument Corporation. Among the new features is a simplified chart frame which swings out on straight pivots with the chart always remaining in time sequence. When the frame is opened, the pen lifts automatically. Ruggedly constructed with aluminum support rods, the frame will withstand hard usage. The speed is approximately 1½ seconds to cross the chart on 60 cycle operation, and the accuracy within plus or minus ¼ percent, with higher accuracies available.

Circle No. 12 on Postcard

Venturi Principle Mixer

A slurry mixer, operating basically on by National Foam System, Inc., and is the Venturi principle, is being offered readily adaptable to almost any type of materials and liquids. It has no moving parts. A hopper feeds the powder into the liquid at optimum rates and pressures predetermined by actual tests of the materials and liquids to be used. Liquids can be handled at a great variety of temperatures, and in normal practice, one mixer can introduce from 10 to 200 pounds of dry material per minute into a similar number of gallons of liquid.

Circle No. 13 on Postcard

Refrigeration Compressors

A new bulletin #C-1100-B38 on Ammonia Refrigeration Compressors has been published by Worthington Corporation. Specifications, pictures and descriptions of the company's line of units is included. A request on your company letterhead will make the bulletin available.

Circle No. 14 on Postcard

Low Carbon Nickel Steel

"Some properties of Low Carbon 8½ Percent Nickel Steel" is the latest booklet issued by International Nickel Company. The booklet describes a ferritic steel that is resistant to the embrittling effects of low temperatures (—320° F.) and which can be welded and fabricated under somewhat the same conditions as engineering steels. Twenty tables and charts depict the mechanical properties and the effects of heat treating and welding.

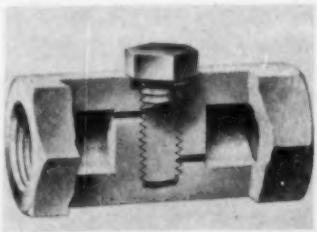
Circle No. 15 on Postcard

Revised Catalog Section

Black, Sivalls & Bryson, Inc. have announced the publication of a revised edition of the Pilots and Controllers Section of their BS&B Climax Control Equipment Catalog. This section shows complete lines of BS&B Climax time cycle controllers, pressure controllers, manual remote controllers, vacuum pilots and safety shut-off pilots. The contents are arranged for easy reading and are illustrated with sectional drawings and photographs.

Circle No. 16 on Postcard

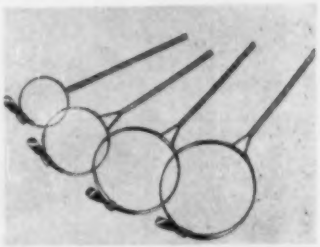
Snubber, Pulsation Damper



A new air flow snubber and pulsation damper has been announced by King Engineering Corporation. This unit provides a controlled slow rate of flow of compressed air or gas for operation of continuous-reading hydrostatic instruments and for purging pneumatic instrument lines. It also protects pneumatic testing and gaging equipment against damage that might result from surge pressures, by providing a flow restriction in the line. The snubber is also used as a pulsation damper for pressure gages, recorders, manometers, and similar instruments. Placed in the line between the instrument and the pressure source, the snubber damps or "smooths out" pulsations so that the instrument gives a steady reading. Full details are available in Bulletin 317.

Circle No. 17 on Postcard

Stainless Steel Clamps



Made of corrosion-resistant stainless steel, the new Labline Varigrip clamp holds breakers, Dewar flasks, vacuum vessels. Manufactured by Labline, Inc., it serves as a funnel holder or support ring, supports extraction apparatus, heating mantles, gas cylinders, distillation columns, resin reacting kettles and large glass tubing. It is always rigid, employing no chains or other accessories and is quickly adjusted with a large flat thumb screw. The clamp is available in four sizes.

Circle No. 18 on Postcard

Laboratory Equipment Data

Andrew Technical Service has issued three new bulletins dealing with laboratory equipment. Bulletin 570 describes a variety of instruments, including flowmeters, evaporators, McLeod gauges, electric and air-power stirrers, microburet, manostats, laboratory carts, proportioning pumps, and a new type of utility protective matting. Bulletin 574 gives detailed specifications and performance data on two models of vacuum pumps for general industrial and laboratory application. Bulletin 576 describes corrosion-resistant circulating pumps with body blocks and interchangeable liners in a variety of materials to meet a wide range of service.

Circle No. 19 on Postcard

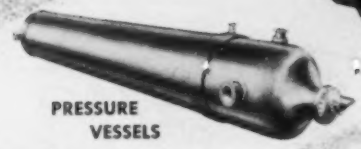
Temperature Resistant O-Rings

The latest Parker Appliance Company catalog describes and gives complete data and dimensions for precision O-rings molded of Parkone compounds for extreme temperature resistance. Parkone O-rings combine suitable mechanical characteristics with resistance to ambient temperatures in the —100° F to 500° F. range, and are also useful in static sealing applications involving resistance to oxidation, to the solvent action of high analine oils and hydraulic fluids, or to rapid aging.

Circle No. 20 on Postcard

HEADQUARTERS FOR HEAVY STEEL FORGINGS

STEEL ROLLS



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PRESS CYLINDER

RINGS

Whatever your needs for heavy steel forgings in industry, Midvale can assure you of the finest in craftsmanship, precision and ultimate performance. Whether it is weldless gear rings for turbine speed reduction . . . cylinders for hydraulic presses . . . weldless high-pressure vessels for oil refining, gas reactions and steam generation or hardened and ground steel rolls for cold rolling carbon and alloy steel, stainless steel, aluminum, copper, brass, zinc, foil, paper, linoleum, plastics and rubber . . . Midvale engineers can help you design them. Midvale craftsmen, with the most modern equipment, will build them to your most exacting specifications. Put your heavy forging problems in our hands.

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Ceramic Metal Coating

How industry can conserve strategic materials and extend the life of metals used at high temperatures through the use of ceramic coatings is explained in a new brochure published by Solar Aircraft Company. Included is a comprehensive outline of the benefits, design features, and properties of Solaramic coatings, along with examples of uses of the Solaramic Process in both aircraft and industrial applications. Methods of application to metal parts is fully discussed.

Circle No. 21 on Postcard

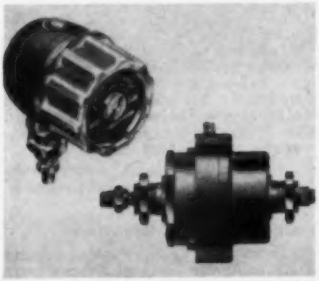
Hows, Whys of Fuel Knock

New information on the basic "hows and whys" of fuel knock is contained in a 30-minute sound movie issued by Ethyl Corporation. The film, "Fundamentals of Fuel Knock," is a cine-graphic progress report on a combustion research project which Ethyl is sponsoring at the Sloan Laboratories of Massachusetts Institute of Technology.

Past research has established a definite connection between knocking combustion and certain chemical reactions which take place in what is technically known as the "end-gas." The current work at MIT, and the contents of the film, are concentrated on the important end-gas reactions. A permanent record of tests is made by a special high speed camera through a quartz window. At a rate of 10,000 frames per second, it photographs the combustion reactions as they take place. The new film contains sequences from a number of tests, showing these split-second reactions in slow motion.

Circle No. 22 on Postcard

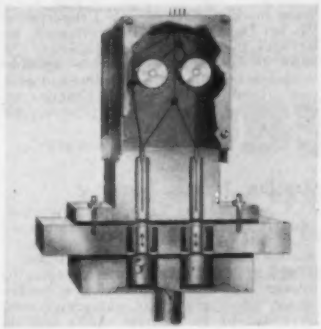
Positioning Control System



Hydrotorque, a hydraulic positioning control system designed for extreme accuracy and power at remote distances, has been announced by The Farris Hydrotorque Corporation. The system will hydraulically position valves, throttle, engine speeds, winches and brakes, diesel engines, metering nozzles and a variety of other mechanical devices. Hydrotorque is a single tube system independent of outside energy, and transmitters and receivers can be supplied in a wide variety of combinations and in many variations of mounting methods. Calibration of dials is to custom requirements.

Circle No. 23 on Postcard

Gas Analysis



Designed to meet the high standards of speed and accuracy of large industrial power plants and central stations, The Hays Corporation has announced the availability of a new CO_2 recorder. Because of the rapid change of sample gas in the gas passage system, the small volume of gas in the analyzing cell, and the continuous connection between the analyzer and the recording pen motor, the Hays Condu-Therm CO_2 recorder achieves five second response to changes in the CO_2 content of the sample gas. Electronic type operation frees the instrument of the step action and delicate construction commonly found in galvanometer operated instruments and also adds greater speed, power and magnification, while assuring high accuracy and permanency of calibration.

Circle No. 24 on Postcard

Acid-Proof Materials

Three descriptive and technical bulletins on acid-proof materials and construction are being offered by Aqua-Therm, Inc. Bulletin No. 139 discusses Eonite pipe and fittings, made of furan resin material reinforced with laminations of chemical glass fabric cloth, for handling most mineral acids, alkalis and organic solvents. Bulletin No. 160 discusses the acid-proof construction of pickling and plating tanks, process tanks, vessels, and towers, pickling and plating basins, acid-proof floors. Bulletin No. 190 covers Eonite lacquer, a coating to protect interior or exterior surfaces from the corrosive effects of gases, vapors, mists, and liquids.

Circle No. 25 on Postcard

Process Controllers Booklet

Eight types of the Model 40 Controller, used in industrial process applications, are described in a new bulletin issued by The Foxboro Company. Each instrument is pictured with a typical process diagram and a characteristic chart record. A section is devoted to the five types of control action available with the Model 40, with control mechanisms for each type diagrammed and explained. Specifications, controller air-connections, case dimensions, measuring elements, safety shutdown systems and other features are included.

Circle No. 26 on Postcard

Compressed Air Coolers

Young Supercharger Air Intercoolers, designed for cooling compressed air between the supercharger blower and the air manifold leading to cylinders of engines are described in a new Catalog No. 1652, released recently by the Young Radiator Company. Supercharger air cooling is performed in a tube and fin cooler, where the hot air passes over the finned surface while the cooling water circulates through the tubes. The cooling fluid can be either fresh or sea water.

Circle No. 27 on Postcard

Instrument Sensing Units

Bulletin T/C 9 is the new 1952 edition of the Wheelco Data Book and Catalog containing prices, application recommendations and pertinent information concerning instrument sensing units and associated accessories produced by Wheelco Instruments Division of the Barber-Colman Company. Essential data pertaining to making, checking, selecting and ordering thermocouples, wire sizes and resistances and temperature-milli-volt curves make this manual handy in applying indicating, controlling and recording instruments.

Circle No. 28 on Postcard

Fabrication Material Data

A bulletin outlining the properties and uses of Permanite, a furfuryl alcohol resin manufactured by Maurice A. Knight Company, has recently been made available. This material is used in the fabrication of corrosion proof chemical equipment. Permanite, reinforced with chemical Fiberglas, is strong and products can be made without pressure over simple forms.

Circle No. 29 on Postcard

Nonclogging Viscometer

The Norcross Corporation has developed a viscometer measuring element for solutions that build up a coating that normally interferes with the accurate measuring of viscosity by industrial viscometers. The new model is particularly suitable for process control applications where these solutions tend to solidify when exposed to air. The element is mounted vertically with the liquid level passing through the rod structure. A normal coating on the rod at the surface of the liquid will not interfere with the operation of the instrument and this deposit buildup can be easily removed when necessary because of the open construction. The new model will function with any of the company's existing recording or recording-controlling equipment.

Circle No. 30 on Postcard

Bulk Plant Petroleum Meter

The new 4-Inch Red Seal Meter, manufactured by Neptune Meter Company for high capacity bulk plants, now offers the Auto-Stop delivery feature previously available only with the smaller Red Seal Meters. The Auto-Stop automatically cuts off flow at the desired gallonage. Designed for low loss of head, the new Auto-Stop valve is cushioned with a double trip to cut off high rates of flow smoothly and accurately. The meter is available with four types of weatherproof registers, including the Auto-Stop Print-O-Meter. Capacity of the Type C meter is 650 gpm without Auto-Stop, 500 gpm with it.

Circle No. 31 on Postcard

Plant Maintenance Coatings

A bulletin describing a dozen different special coatings for plant maintenance use has been issued by United Laboratories, Inc. It points out the use of various industrial products for solving such problems as skidproofing, rust prevention, painting over damp areas, weatherproofing and decoration of exterior masonry, interior waterproofing, painting over hot surfaces, protection against acids, chemical fumes and other special maintenance work.

Circle No. 32 on Postcard

Non-Warping X-Ray Cassettes

Poor contact between screens and film in ex-ray film cassettes caused by the warping of the cassette front has been overcome by the new GE "Permacon" magnesium-front 14x17 cassette. The new product is offered by the X-Ray Department of General Electric Company. Use of air bags and other methods of insuring permanent contact between screen and film are rendered unnecessary by the use of magnesium. Radiographic results are markedly improved by the uniformity and dependability of contact. The use of a Permacon cassette requires no change in x-ray technic. Sheets of magnesium are also available with which to replace bakelite in cassettes now in use. The new front is virtually unaffected by heat and moisture.

Circle No. 33 on Postcard

Nickel Deposit Properties

Another International Nickel Company booklet, "Mechanical Properties of Nickel Deposits," has been released, describing the wide range of properties that may be obtained in electro-deposited nickel by varying the solution and plating procedure. The booklet contains numerous charts, tables and photo-micrographs.

Circle No. 34 on Postcard

Tractors, Trailers, Trucks

A new product catalog is now available from the Mercury Manufacturing Company on their entire line of current model tractors, trailers, fork lift trucks, platform lift trucks, and load carrying trucks. The reference catalog is broken down into three major categories, each preceded by an analysis of the applications and merits of each handling system.

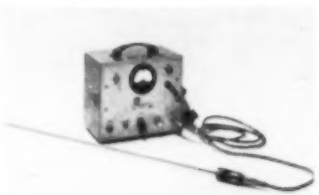
Circle No. 35 on Postcard

New Laboratory Equipment

A new edition of "What's New for the Laboratory," 15th in the series, has been announced by the Scientific Glass Apparatus Company, Inc. Among the featured items in an adjustable type thermometer, glass tubing manipulator, "Mighty Midget" stirrer, 12-Place Angle Head (for an International Centrifuge), simplified extraction apparatus, Coleman, Beckman and Precision instruments, vacuum pump and sectional metal furniture.

Circle No. 36 on Postcard

Turbulent Flame Indicator



The availability of the Phillips 66 Flamometer has been announced by Phillips Petroleum Company. This new instrument is designed to detect, amplify and indicate electrical signals in the audio frequency range, generated by turbulent flames. Experimental as yet, it is expected to be a useful tool in locating flame zones and boundaries. It consists of a detecting probe (ceramic tip supported by a metal rod) and an electrical circuit. No significant signal is registered unless the probe is in an actual flame zone which is both ionized and turbulent. Response time is of the order of a millisecond. Signal detection is not materially affected by the temperature of the detecting tip. Probes have been designed to withstand a wide range of mechanical or thermal loads over long periods of time. The first two stages of the amplifier are shock-mounted to minimize microphonic interference.

Circle No. 37 on Postcard

Self-Closing Push Valve

King Engineering Company has announced the availability of the King Self-Closing Push Valve, for use in gas and air lines where manual control of an intermittent flow is required and where there must be no leakage through the valve or around the valve stem. The valve is opened by pressing a knob on the valve stem, and closes automatically when the knob is released. It has no compression packing and requires no adjustment, being sealed by neoprene O-rings. The valve is available in two styles: Model PV (photo above), for mounting on panels of any thickness up to 7/16-inch, and Model LV for in-the-line mounting. Discharge rate is 25 to 30 cubic feet per minute at a pressure drop 100 pounds per square inch. Bulletin 304 gives complete details.

Circle No. 38 on Postcard

Flow Rate Regulators Data

A new bulletin, published by the W. A. Kates Company, describes in detail the company's line of flow rate regulators. The principle of operation employed by all Kates Regulators is clearly illustrated in the bulletin, which also shows why the simplicity of this principle permits flexibility in servce. The bulletn also describes a few of the applications which have successfully utilized these regulators.

Circle No. 39 on Postcard

Friction Locating Stethoscope

The solution to problems of locating friction noises in bearings, pistons, gears, ratchets, cams, clutches, traps, pipe lines, valves, and other mechanisms is simplified by a new, portable, electronic instrument manufactured by Anco Instrument Division. Known as the Elec-Detec, this electronic stethoscope employs a metal probe which serves as a microphone to localize the source of tell-tale noise. According to the manufacturer, the electric amplifier and the sensitivity control on the Elec-Detec make it possible to detect sound at low speed that otherwise would be heard only at high speeds. The instrument is furnished complete with high impedance type headphones, batteries, and leather carrying case.

Circle No. 40 on Postcard

Complete Oxygen Plants

Purchase of all process and patent rights covering the Elliott Oxygen System for the production of tonnage oxygen and high purity nitrogen, and the availability of complete plants of this type on a turn-key contract basis has been announced by The H. K. Ferguson Company. Dr. Irving Roberts, who participated in the development of the Elliott System, has been retained by The Ferguson Company to offer technical assistance or consultation to companies desiring to purchase the oxygen plants.

The system is mechanically simplified, operates as reduced loads without sacrifice in efficiency, and is immune to possible dangers of acetylene explosions. Controls are automatic and will automatically adjust the system to any oxygen demand. Complete details are available upon request.

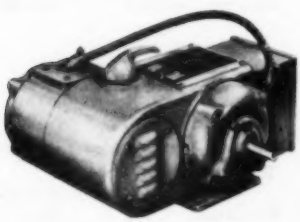
Circle No. 41 on Postcard

Seamless Cold Drawn Steel

The advantages that accrue to manufacturers through the use of tubing in the production of hollow precision parts are outlined in a new data card published by the Tubular Products Division of The Babcock & Wilcox Company. In addition to pointing out the savings in time and costs that come through the use of seamless cold-drawn carbon steel mechanical tubing for the production of such parts, the bulletin presents tables of tolerances and mechanical properties of such tubing. The bulletin is identified as TB 339.

Circle No. 42 on Postcard

Variable Speed Motors



A new development in single phase variable speed motors in fractional horsepower has been announced by U.S. Electrical Motors, Inc. As a modification of the company's Type VA Varidrive line, the new motor permits the use of 110 or 220 volts. It is designated as Type VA-C Varidrive and is made in ¼, 1/3, ½ and 3/4 horsepower. The lightweight motor provides speeds in a 10:1 ratio with the range from 4 to 10,000 rpm. Merely by turning a convenient control dial, the motor's speed can be instantly changed to a desired speed without stopping. An illustrated Bulletin, No. 1601 giving full details may be obtained.

Circle No. 43 on Postcard

Electronic Winding Tester

A newly-developed portable electronic winding tester has been announced by Columbia Technical Corporation. This new production, maintenance and field-use, and laboratory instrument is designed to detect faults in and to prevent breakdowns of electrical motors and generators of all sizes and types, coils, and similar electrical equipment.

Known as the PMD Tester, it enables the user to detect the location as well as the nature of an electrical fault in any type of winding. It can be used on either AC or DC devices. The test probes generate their own field in the probes. Complete details are available from the manufacturer.

Circle No. 44 on Postcard

Industrial Wired Television

Because of the rapidly growing interest in industrial television, Diamond Power Specialty Corporation has developed their Model 300-B Utiliscope. The Utiliscope consists of three separate units, a camera, power unit and monitor, with the whole set-up weighing 133 pounds. The camera can be mounted upon a tripod for mobility, can be stationed as much as 100 feet from the power unit, and focuses from 10 inches to infinity. The power unit and monitor may be as far as 1500 feet apart without booster amplification. The unit has a resolution power of 300 lines horizontal and 300 lines vertical. Shock mounted, it can be operated with power requirements of 115 volts, 60 cycle AC, 225 watts. An illustrated brochure giving complete details is available.

Circle No. 45 on Postcard

Ethylene Carbonate Samples

Jefferson Chemical Company, Inc., has anonounced that it has begun the manufacture of a new chemical, ethylene carbonate, in pilot plant quantities. Samples of this material and technical bulletins describing its properties are available to the trade upon application. Ethylene carbonate is an odorless, colorless, low-melting solid, non-hygroscopic and non-corrosive. It has outstanding properties as a solvent for acrylonitrile polymers, lignin, nitrocellulose, nylon, cellulose acetate and other polymeric materials. Additional information is available upon request.

Circle No. 46 on Postcard

Horizontal Service Pumps

The use of standard mechanical shaft seals, instead of conventional stuffing boxes, thereby obtaining savings in floor space, shorter shaft lengths, improved performance characteristics and easier pump servicing, is the feature of a new line of horizontal, split-case, general-service pumps recently announced by Peerless Pump Division, Food Machinery and Chemical Corporation. This line of pumps, designated as the Peerless Type AS, is available in discharge sizes from 1¼-inches through four inches. Capacity range is up to 750 gpm and head range is up to 230 feet. General application is for pumping water and clear liquids up to 200° F. where no solids are in suspension. Additional literature is available upon request.

Circle No. 47 on Postcard

Addenda Errata Booklet

Tube Turns Inc., manufacturers of welding fittings and flanges, has announced the release of its Addenda Errata Booklet, covering revision, typographical errors, changes in code affecting certain data, etc., for use with its Catalog No. 211. It is designed to fit the pocket at the back of the catalog. Code changes, plus an additional column of design information, have also made necessary the preparation of a new Design Properties of Pipe table, superseding table No. 2 in the catalog.

Circle No. 48 on Postcard

Glass Tubing Manipulator

Developed by Labline, Inc., to eliminate hazards of inserting glass tubes and thermometers in stoppers, the new Labline Grip-Safe provides a gentle gripping action which permits sliding of tubing into stoppers without the excessive or uneven pressure which breaks the tubing. Even if the tubing should break, Grip-Safe protects the hands, wrists and knuckles from injury. It accommodates most sizes of commonly used tubing as well as irreguar shaped tubing such as T's and L's. It may also be used to break tubing to desired length after marking with a file or cutter.

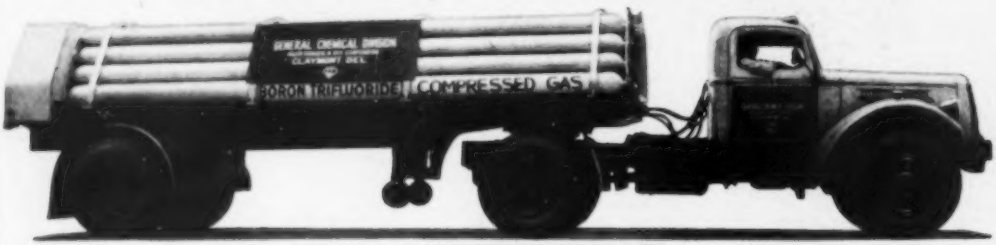
Circle No. 49 on Postcard

NOW, GENERAL CHEMICAL BRINGS INDUSTRY THIS

Versatile Catalyst

BORON TRIFLUORIDE

in Many Forms...in Tonnage Quantities*



A LABORATORY CURIOSITY less than a decade ago, now an industrial chemical of tremendous significance as a catalyst—that is the story of Boron Trifluoride as developed by General Chemical's fluorine research program.

Today, the catalytic properties of Boron Trifluoride . . . both as a compressed gas and in its various complexes . . . are being utilized in many major industrial fields. These include petroleum, synthetic rubber, resins, solvents, plastics, dyestuffs, metallurgy, etc. With it, many hitherto impossible operating problems involving organic reactions are being solved.

To meet every processing need, General Chemical produces Boron Trifluoride both as a gas and in a wide range of complexes. Recently, General began regularly-scheduled tonnage shipments of the compressed gas by tank truck, marking another milestone in the expanding use of this new industrial chemical.

Listed at the right are many of the reactions in which General's BF_3 is now being utilized. If your operations involve these or similar techniques, you may find it advantageous to investigate Boron Trifluoride and its complexes.

For further information, for experimental samples of any of the products listed, or for confidential discussion of your particular needs, consult the nearest General Chemical office serving you.

Present or Potential Uses of BF_3 as a Catalyst

POLYMERIZATION

ALKYLATION

ESTERIFICATION

ISOMERIZATION

CYCLIZATION

ACYLATION

BASIC CHEMICALS

GC

FOR AMERICAN INDUSTRY

*** GENERAL CHEMICAL'S BF_3 PRODUCTS**

Commercially Available in Tonnage Quantities

Compressed Gas	
Phenol Complex	**(Liquid)**
Etherate Complex	**(Liquid)**

Available in Limited Commercial Quantities

Ammonia Complex	**(Solid)**
Diacetic Acid Complex	**(Liquid)**
Di-normal Butyl Ether Complex	**(Liquid)**
Dihydrate	**(Liquid)**
Piperidine Complex	**(Solid)**

Other Complexes

In addition, extensive research and production facilities place General Chemical in a preferred position to work with you in development of other BF_3 complexes to meet individual specifications.

GENERAL CHEMICAL DIVISION

ALLIED CHEMICAL & DYE CORPORATION

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Offices in Principal Cities from Coast to Coast

Pneumatic Controls Calibrator

Republic Flow Meters Company's portable pneumatic instrument calibrator is designed for calibration and testing of low pressure instruments and controls such as flow meters, draft gages, differential pressure transmitters, with ranges 0-20 inches water-pressure, vaccum or compound. Essentially a manually operated force-balance, the calibrator consists of a standard chemical weight scale and an oil sealed bell. Weights on the scale are balanced against an opposing air pressure in the bell. Thus, bell air pressure can be determined with laboratory scale accuracy and used as a standard for the calibration of an instrument. The unit has rubber tires, enameled metal frame and a protective cover. All necessary weights are furnished with the instrument.

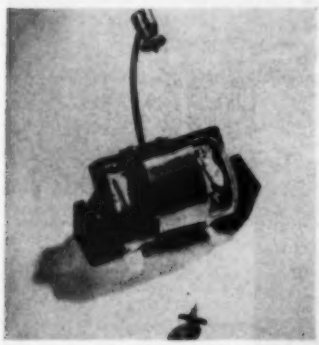
Circle No. 50 on Postcard

Water Treating Conditioner

The Pur-O-San Company, a Division of Bradford Chemical Company, has announced Pur-O-San Extra for use in heat exchangers and condensers. According to company officials, extensive field and laboratory tests have proven Pur-O-San Extra to be a complete conditioner for treating water used in heat exchangers, and readily soluble and providing full protection regardless of the characteristics of the water used. When added to water, it is readily soluble, non-toxic, non-volatile, heat-stable, and eliminates free oxygen.

Circle No. 51 on Postcard

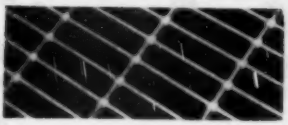
Industrial Instrument Pens



New industrial instrument pens that eliminate flooding and reduce paper plugging and choking have been designed by Minneapolis-Honeywell Regulator Company for their strip chart electronic instruments. The new pens have removable tips and a new reservoir construction which eliminates flooding because the effective ink level is always below the writing tip. The pen operates with decreased pressure on the instrument chart, tending to reduce paper fibre choking. Thorough cleaning is made easy by a simple disassembly, and the new design fits on standard pen carriages, permitting improved performance for already installed instruments.

Circle No. 52 on Postcard

Open Steel Welded Grating



The Lemp Metal Grating Corporation has produced a new open steel welded grating called Klemp-Krest. It features round steel cross bars so formed as to provide a peak, or crest, on the top side of the bar. These bars are placed at right angles on top of flat bearing bars set on edge and then electro-welded under great pressure. The roundness of the bar which forms cross braces between the bearing bars gives greater tensile strength and makes a stronger weld, thus effecting good distribution of load, or impact, in every direction over the area of each section. The crested top provides a ridge between each bearing bar; thereby adding to the nonslip characteristics.

Circle No. 53 on Postcard

Graphitization Research Study

A booklet just published by Edward Valves, Inc., comprehensively discusses the graphitization phenomena encountered in systems operated at elevated temperatures in the power and processing industries.

Based on a research program in the company's laboratories which has extended over the last 10 years, this research study describes in detail the nature of graphitization and its effects and lists preventive and corrective measures. Illustrated with photomicrographs of metallurgical specimens picturing the graphitization process, the booklet also contains eutectic diagrams and graphs illustrating the effect of temperature, time and other variables on graphitization.

Circle No. 54 on Postcard

Variable Area Flow Meters

A catalog now ready for distribution describes variable area flow meters with newly developed, precise, economical, tapered metal metering tubes. The publication discusses Armored Flowrator Meters which are designed for both high temperature and high pressure and for use where liquid hammer and hazardous fluids make ordinary meters impractical or dangerous. Besides containing complete data on Fischer & Porter Company's line of Armored Flowrator Meters, this catalog devotes an entire section to meter extensions and extension combinations.

Circle No. 55 on Postcard

Tachometer Heads Data

The Metron Instrument Company has announced the publication of Metron Technical Data Sheet No. 57M describing their Series 57M heavy duty Tachometer Heads for measuring low speeds, either rotational or linear.

Circle No. 56 on Postcard

Tap Water Demineralizer

The A. E. Tomkins & Company is now marketing a Series L52 Hydrion Demineralizer Units for the conversion of ordinary tap water to water of chemical ionic purity of distilled water. An available manufacturer's bulletin includes details, specifications and performance data for both the Service model and the General model Hydrion units with lists of representative users and suggested fields of application. The Service model has a capacity to produce pure water at a rate up to five gallons per hour. Both models utilize refill charges which upon exhaustion are discarded and a new refill is charged into the unit. More detailed information is available upon request.

Circle No. 57 on Postcard

Timesaving Blind Lockbolts

Huck Manufacturing Company, producers of the Blind Lockbolt, claims this product accomplished repairs in only nine hours, where conventional methods would have required 668 hours at a major U. S. Air Force base. The only heat treated alloy steel blind fastener with a positive swaged lock, Huck Blind Lockbolts have exceptional strength and pull-together. They are approved by the United States Air Force Air Material Command and the U. S. Navy Bureau of Aeronautics for use in aircraft structures where aluminum alloy blind rivets do not possess sufficient strength. Complete descriptive literature is available to all engineers and Army, Marine, Navy and Air Force personnel upon request.

Circle No. 58 on Postcard

Line Leak Repair Clamp

For permanent repair on oil and gas lines, a new HiPressure leak repair clamp has been developed by R. H. Baker & Company, and designed for repairing corroded pipe sections, leaks, splits and breaks which do not extend fully around the circumference of the pipe. Bolts slip through cone-shaped, extra large bolt holes, then the bolts are drawn up as needed to stop the leak. A flexible corrosion resistant band assures permanent repairs even on out-of-round and damaged pipe. The clamp has a neoprene rubber gasket and is constructed with bands of 36-ounce heavy copper, 18-gauge galvanized iron or 20-gauge stainless steel.

Circle No. 59 on Postcard

Licked before they start!

BLAW-KNOX FOG SYSTEMS DON'T GIVE FIRES A CHANCE TO GROW UP

Chemical and petroleum fires strike fast with little or no warning. But not so fast that a Blaw-Knox Fog System actuated by rate-of-rise thermostats can't knock 'em out with a smothering blanket of fog *before* they really get started.

A Blaw-Knox System engineered for the fire hazards existing in or around your plant is a most effective weapon against fire's toll. On the job 24 hours a day, it protects your property as well as products essential to our national economy.

Glad to consult with you and submit an estimate without obligation.

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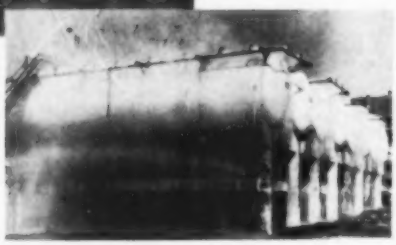
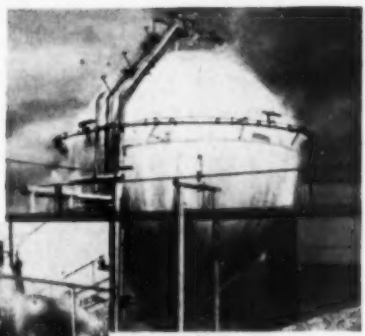
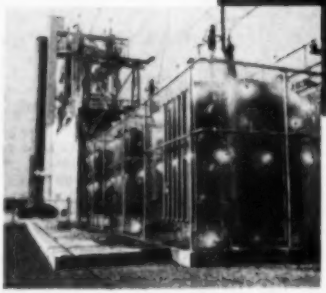
POWER PIPING AND SPRINKLER DIVISION
829 Beaver Ave., N.S., Pittsburgh 33, Pa.







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Catalogs AND EQUIPMENT Literature OFFERED IN THIS ISSUE'S ADVERTISEMENTS

Copies may be obtained easily and without cost by using Reader Service Postcard. Just circle on the card the identifying key number of each item in which you are interested. Postcards are opposite page 152.

AIR PREHEATER—Information. The Air Preheater Corp. See pages 12 and 13.
Circle A1 on postcard.

TUBE CLEANERS—Details. Airetool Manufacturing Co. See page 170.
Circle A2 on postcard.

AIRCOOLERS—Bulletin. Alco Products Division, American Locomotive Co. See page 135.
Circle A3 on postcard.

HEAT INSULATION—Information. Armstrong Cork Co. See page 60.
Circle A8 on postcard.

STEAM TRAPS—Booklet. Armstrong Machine Works. See pages 36 and 37.
Circle A9 on postcard.

HYDRAULIC CONTROLS—Bulletin 120. Askania Regulator Co. See page 215.
Circle B1 on postcard.

TUBE ENGINEERING DATA—Bulletins. Tubular Products Division, The Babcock & Wilcox Co. See pages 148 and 149.
Circle B3 on postcard.

ENGINEERED HEAT CONTROL—Information. Baldwin-Hill Co. See page 212.
Circle B7 on postcard.

WEYBLAST NOZZLE—Information. Big Three Welding Equipment Co. See page 25.
Circle C2 on postcard.

DIAPHRAGM CONTROL VALVES—Catalog Section 105. Black, Sivalls & Bryson, Inc. See page 30.
Circle C4 on postcard.

STEEL GRATING—Bulletin 2365. Blaw-Knox Co. See page 183.
Circle C6 on postcard.

ELECTRONIC RECORDER—Catalog P1245. The Bristol Co. See page 17.
Circle C8 on postcard.

DUST RECOVERY SYSTEMS—Bulletin. Buell Engineering Co. See page 147.
Circle D1 on postcard.

MECHANICAL SEAL—Details. Byron Jackson Co. See page 127.
Circle D2 on postcard.

CENTRIFUGAL COMPRESSORS—Catalog. Carrier Corp. See page opposite 189.
Circle D3 on postcard.

SEAL UNIONS—Catalog 11. Catawissa Valve & Fittings Co. See page 177.
Circle D5 on postcard.

GATE VALVE—Catalog 10. The Chapman Valve Mfg. Co. See page 131.
Circle D6 on postcard.

ALUMINUM WEATHERPROOF JACKETING—Sample. Childers Manufacturing Co. See page 26.
Circle D9 on postcard.

STEAM TRAPS—Details. The Clark Mfg. Co. See page 130.
Circle E2 on postcard.

PROTECTION FOR HEAT EXCHANGER TUBE ENDS—Booklet. Condenser Service & Engr. Co. See page 215.
Circle E3 on postcard.

MATERIAL HANDLING EQUIPMENT—Data. Dempster Brothers. See page 33.
Circle F1 on postcard.

SAFETY PROGRAM FOR REFINERIES—Serial A-2848. E. I. du Pont de Nemours & Co. See insert pages 156 and 157.
Circle F4 on postcard.

STAINLESS AND HIGH ALLOY PRODUCTS—Catalog. Electric Steel Foundry. See page 5.
Circle F7 on postcard.

TUBE CLEANERS—Bulletin Y-29. Elliott Co. See page 119.
Circle F8 on postcard.

FLOWRATOR METERS—Information. Fischer & Porter Co. See page 35.
Circle G1 on postcard.

CONSOTROL CONTROLLER—Bulletin 463. The Foxboro Co. See pages 136 and 137.
Circle G5 on postcard.

MECHANICAL-DRIVE TURBINES—Bulletin GEA-4955A. General Electric Co. See pages 10 and 11.
Circle G7 on postcard.

CASTABLE REFRACTORIES—Information. A. P. Green Fire Brick Co. See page 214.
Circle G8 on postcard.

PROPORTIONING PUMPS—Catalog U-52. Hills-McCanna Co. See page 209.
Circle H3 on postcard.

PNEUMATIC TRANSMITTER—Bulletin. Instruments, Inc. See page 196.
Circle H6 on postcard.

SIDE ENTERING MIXERS AND AGITATORS—Bulletin P-72. International Engineering, Inc. See page 145.
Circle H7 on postcard.

WIRE MESH PRODUCTS—Details. The C. O. Jelliff Mfg. Corp. See page 192.
Circle H9 on postcard.

VESSEL GASKETS—Information. Johns-Manville. See page 24.
Circle J1 on postcard.

ASBESTOS-CEMENT SHEETS—Data. Keasbey & Mattison Co. See page 39.
Circle J3 on postcard.

CASCADE REACTOR—Information. The M. W. Kellogg Co. See pages 20 and 21.
Circle J4 on postcard.

INERT GAS GENERATORS—Bulletin 1-10. The C. M. Kemp Mfg. Co. See page 126.
Circle J5 on postcard.

STEEL GRATING—Catalog. Kerrigan Iron Works, Inc. See page 181.
Circle J6 on postcard.

WELL INSTALLATION SERVICES—Data. Layne & Bowler, Inc. See page 32.
Circle J9 on postcard.

ELECTRONIC RECORDERS—Catalog ND46(1). Leeds & Northrup Co. See page 8.
Circle K2 on postcard.

PROPORTIONAL VALVES—Bulletin 700-2. Minneapolis-Honeywell Regulator Co. See page 195.
Circle L2 on postcard.

STEAM TURBINES—Bulletin T-122. Murray Iron Works Co. See page 187.
Circle L4 on postcard.

GRAPHITE GROUND ANODES—Catalog Section S-6510. See page 162.
Circle L5 on postcard.

STEAM TRAPS—Catalog 751. W. H. Nicholson & Co. See page 183.
Circle L6 on postcard.

DRUM RECONDITIONING—Booklet F7629. Oakite Products, Inc. See page 212.
Circle L7 on postcard.

TUBING. Bulletin. Pacific Tube Co. See page 143
Circle M1 on postcard.

TRANSPARENT GAGE, CYCLING JET PUMPS AND EJECTORS—Catalog 35, Bulletins 5030 and 512. Penberthy Injector Co. See page 216.
Circle M4 on postcard.

PROCESSES FOR PURIFICATION OF PETROLEUM—Data. Petrolite Corp. See page 41.
Circle M7 on postcard.

SCIENTIFIC LABORATORY EQUIPMENT—Bulletin 50. Refinery Supply Co. See page 185.
Circle N4 on postcard.

STAINLESS STEEL—Information. Republic Steel Corp. See page 193.
Circle N6 on postcard.

BALL VALVES—Folder V-4. Rockwood Sprinkler Co. See page 3.
Circle P3 on postcard.

SCREW PUMPS—Data. Sier-Bath Gear and Pump Co. See page 138.
Circle P7 on postcard.

PUMP VALVES—Catalog. Sims Pump Valve Co. See page 150.
Circle P8 on postcard.

CRANE CARRIERS—Data. Six Wheels, Inc. See page 134.
Circle P9 on postcard.

PROPORTIONING PUMPS—Catalog UP-52. The Edward Soph Co. See page 209.
Circle Q1 on postcard.

GUM INHIBITORS—Information. Tennessee Eastman Co. See page 141.
Circle Q5 on postcard.

STEAM TURBINES—Bulletin S-116. The Terry Steam Turbine Co. See page 207.
Circle Q6 on postcard.

PIPE INSULATION—Bulletin 76-109. Union Asbestos & Rubber Co. See page 54.
Circle R1 on postcard.

SCRAPED SURFACE EXCHANGERS—Bulletin PE-1. Henry Vogt Machine Co. See page 205.
Circle R3 on postcard.

PROCESS VALVES—Bulletin 698. W-K-M Company. See page 194.
Circle R4 on postcard.

VERTICAL TURBINES—Data. Whiton Machine Co. See page 175.
Circle R8 on postcard.

FINNED TUBE—Bulletin. Wolverine Tube Division. See page 186.
Circle R9 on postcard.

STEAM TRAPS—Bulletin T-1740. Yarnall-Waring Co. See Second Cover.
Circle S4 on postcard.

EXPANSION JOINTS AND FLEXIBLE CONNECTORS—Catalog 47 and Bulletin 351. Zallea Brothers. See page 27.
Circle S5 on postcard.

Practical Design Handbook For Engineers

By

DR. ALOIS CIBULKA

Department of Petroleum Engineering, University of Houston, Houston, Texas

A new, much enlarged edition which includes now three formerly separate publications; namely Refinery Piping Design, Modern Welded Steel Structures and Aerial Cable Tramways.

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Graphite Ground Anodes

THIS major producer has several million square feet of uncoated tank bottoms and hundreds of miles of underground piping. Maintenance was heavy. Studies indicated cathodic protection – *but how?*

The high current necessary to give continuous, positive protection dictated the use of an impressed current system. First estimates favored scrap steel over graphite rods on a cost-per-unit basis.

But experience revealed a multitude of hidden costs and operating difficulties in the installation of steel scrap.

Scrap had to be welded. It required heavy trenching and transportation equipment . . . large labor crews. Bad weather held up men, machines and progress.

Re-evaluation clearly favored a "distributed" system of vertically-installed "National" Graphite Ground Anodes– which were specified for the whole of this large project.

RESULTS

- **Lowest *installed* cost**
- **90% of corrosion leaks eliminated within 5 years of first installation**
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- **Power equipment requirements much lighter**
- **Installation simplified in congested areas**
- **Much lower amortization cost due to longer anode life**

WRITE FOR CATALOG SECTION S-6510

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A Division of Union Carbide and Carbon Corporation

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HEAT EXCHANGERS • PUMPS • VALVES • PIPING • TOWERS • TOWER PACKING • BUBBLE CAPS • BRICK • STRUCTURAL CARBON • SULPHURIC ACID CUTTERS • HYDROCHLORIC ACID ABSORBERS

SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

Fundamental Physical and Chemical Data

The Entropy and Vapor Pressure of 1-Pentanethiol, H. L. FINKE, D. W. SCOTT, M. E. GROSS, GUY WADDINGTON AND H. M. HUFFMAN (The Thermodynamics Laboratory, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Oklahoma), *Jour. Am. Chem. Soc.* **74** (1952), pp. 2804-6.

This is a paper in the series of investigations of the thermodynamic properties of the structurally simple sulfur compounds occurring in petroleum. The authors believe that the experimentally determined entropy of 1-pentanethiol at 298.16° K. as presented in this paper will provide a guidepost in the construction of tables of thermodynamic functions for the n-alkanethiols. In the work reported the low temperature thermal properties and the vapor pressure of 1-pentanethiol were measured. The entropy of the saturated liquid at 298.16° K. was calculated from the heat capacities of the solid and liquid and the heat of fusion at the triple point. An equation is given that accurately represents the vapor pressure of the compound over the temperature range that was experimentally studied. The entropy of the ideal gas was computed.

Ethanethiol (Ethyl Mercaptan): Thermodynamic Properties in the Solid, Liquid and Vapor States. Thermodynamic Functions to 1000° K., J. P. MCCULLOUGH, D. W. SCOTT, H. L. FINKE, M. E. GROSS, K. D. WILLIAMSON, R. E. PENNINGTON, GUY WADDINGTON AND H. M. HUFFMAN (The Thermodynamics Laboratory, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Oklahoma), *Jour. Am. Chem. Soc.* **74** (1952), pp. 2801-4.

The purpose of the studies is primarily to make available accurate thermodynamic functions for the structurally simple members of families of sulfur compounds that are important to the petroleum industry. The present paper describes the results of studies of the thermodynamic properties of ethanethiol. These properties were measured in the solid, liquid and vapor states over the temperature range 14° to 450° K. The entropy of the saturated liquid at 298.16° K. was obtained from measurements of the heat capacity of the solid and liquid and the heat of fusion. Equations are given for the vapor pressure, heat of vaporization, vapor heat capacity in the ideal gaseous state, and the second virial coefficient. The entropy of the ideal gas at one atmosphere pressure and 298.16° K. was calculated. A vibrational assignment is given for ethanethiol.

Thiacyclopropane (Ethylene Sulfide): Infrared Spectrum, Vapor Pressure and Some Thermodynamic Properties, G. B. GUTHRIE, JR., D. W. SCOTT AND GUY WADDINGTON (Thermodynamics Laboratory, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Oklahoma), *Jour. Am. Chem. Soc.* **74** (1952), pp. 2795-2800.

The thiacycloalkanes, or saturated cyclic sulfides, are one group of compounds included in the thermodynamic research program of A.P.I. Project 48A. The present paper gives the results of a study of the first member of the series, ethylene sulfide or thiacyclopropane. The infrared spectrum of the liquid was observed between 2 and 15 μ. The vibrational assignment was calculated. These, together with moments of inertia from microwave measurements, were used to calculate the thermodynamic functions to 1000° K. Vapor pressure was measured from 18° to 88° C., and an equation is given to represent the data. The heat of vaporization at 25° C. was calculated as 7240 ± 50 cal. mole. The heat, free energy and equilibrium constant of formation of the compound at several temperatures to 1000° K. were calculated by use of heat of combustion data for the liquid, the heat of vaporization and the thermodynamic functions.

Vapor Pressure-Temperature Relationships of Sulfur Compounds Related to Petroleum, P. T. WHITE, D. G. BARNARD-SMITH, AND F. A. FIDLER (Research Station, Anglo-Iranian Oil Co., Ltd., Sunbury-on-Thames, Middlesex, England), *Ind. Eng. Chem.* **44** (1952), pp. 1430-8.

The investigators measured the vapor pressure-temperature relationships for 15 alkane sulfides, 8 alkane disulfides, 9 cyclic sulfides, and 3 thiophenes. Several correlations were made relating the boiling points at 760 mm. and the B and C constants of the Antoine equation to the structure of both the alkane sulfides and disulfides. These correlations, at least within a limited range, allow the prediction of the same properties for similar compounds that have not yet been prepared. The latent heats of vaporization of the sulfur compounds were calculated from the vapor pressure data and it is the opinion of the authors that they are accurate within the limits of experimental error. Limited data have been available on the vapor pressure of the various sulfur compounds present in petroleum products, and the results of the present work should be of value because it allows calculations to be made in connection with problems dealing with the separation of sulfur compounds by distillation. The data secured in the work are presented in considerable detail in tabular and graphical form and a bibliography of 21 references is appended.

Evaluation of Flame Speed at Burner Flame Tip, L. C. LICHTY (Yale University, New Haven, Conn.), *Ind. Eng. Chem.* **44** (1952), pp. 1395-8.

The author questions the high flame velocities and large heat transfer effects usually reported for gas flame as from a Bunsen burner. Data taken indicate that there is little transfer to the central mixture lamina before burning other than from its own flame, and the heat transfer from its own flame must be relatively small. The flame tip speed for the actual case studied was of the order of 80 to 90 cm. per second, depending largely on the actual increase in flow area through the flame zone. The data taken on mixture velocities before and product velocities after the flame are reconciled by the assumption of a ram effect, which decreases the mixture velocity before entering the flame and provides part if not all of the pressure rise required for flow through the flame. A bibliography of five references is included.

THESE abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles can be obtained at nominal cost from The Library of Congress, Photoduplication Service, Washington 25, D. C. Complete or limited bibliographies covering special topics by title, by abstract or in complete manuscript will be prepared and furnished by arrangement with The Leslie Laboratories.

Chemical Composition and Reactions

Cyclopentane and Neohexane in Petroleum, ROBERT F. MARSCHNER AND DONALD E. BURNEY (Research Department, Standard Oil Co. (Indiana), Whiting, Ind.), *Ind. Eng. Chem.* **44** (1952), pp. 1406-8.

The work reported comprised the fractionating of selected naphthas through a large column, refractionating the cyclopentane-neohexane concentrate through a small column, and determining the refractive index of successive small fractions boiling at 49° to 50° C. Cyclopentane and neohexane form an azeotrope that boils at 49.1° C. and has approximately 80 percent cyclopentane

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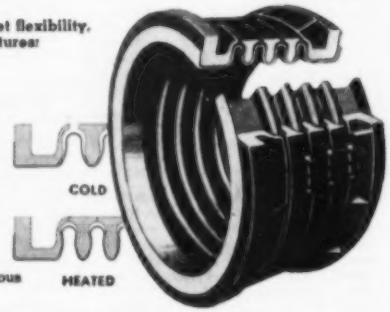

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and 20 percent neohexane by volume. The cyclopentane-neohexane ratio differs widely in different naphthas, and it is an easily identified characteristic because of the close-boiling point or the two components, as well as the azeotrope. Distillations have little effect upon the mixture. Thus the cyclopentane-neohexane fraction can be used as a tracer to determine the probable source of light naphthas or solvent naphthas. The naphthas studied were derived from the Illinois fields, Mid-Continent field, Wyoming field, Houston-Hackberry fields, the Hastings field on the Texas Gulf Coast, and from East Texas. A bibliography of 18 references is given.

The Hydrogenation of Ethylene Over Copper. I. Reproducing the Activity of the Catalyst, CHARLES LAW MCCABE AND G. D. HALSEY, JR. (Mallinckrodt Chemical Laboratory, Harvard University), *Jour. Am. Chem. Soc.* **74** (1952), pp. 2732-4.

The catalyst studied was prepared by the reduction of cupric oxide with hydrogen at 130° C. for four days. The temperature was then gradually raised to 315° C. over a period of three hours and was then lowered and held at 200° C. for five hours. The catalyst was then cooled slowly to room temperature with one atmosphere of hydrogen over it. One of the factors determining the activity of a reduced copper catalyst in the hydrogenation of ethylene is the quantity of chemisorbed hydrogen on the catalyst surface. Results of the work show that this hydrogen is not a reactant. On the contrary, it functions as part of the catalyst. The authors use three different methods of getting different amounts of chemisorbed hydrogen on the surface, and the activity of the catalyst as a function of the amount of the chemisorbed hydrogen is reported. By controlling this coverage of chemisorbed hydrogen the activity of the catalyst can be reproduced to within 5 percent as was shown by a series of 50 runs.

The Kinetics of the Thermal Decomposition of Normal Paraffin Hydrocarbons. IV. Modes of Rupture of the Carbon Chain, K. U. INGOLD, F. J. STUBBS, AND CYRIL N. HINSHELWOOD (Univ. Oxford, Engl.), *Proc. Roy. Soc.* (London) **A208** (1951), pp. 285-91.

The decomposition of a normal higher paraffin yields methane, ethane and propane in amounts that indicate approximately the relative probabilities of the rupture of the carbon chain at various places. If the reaction is inhibited by nitric oxide the proportions are independent of temperature and pressure over ranges of these variables where marked changes would occur if the rupture of the various carbon-carbon bonds corresponded to processes of different activation energy. The probability of rupture decreases with distance from the end of the carbon chain, that is methane is the predominant product and ethane next most predominant. It is suggested that the explanation may lie in the electronic symmetry of the structures of the 2 lowest paraffin hydrocarbons. Consideration of the normal modes of vibration of a long C chain suggests no obvious mechanical reason why rupture at the C_1 or C_2 position should be consistently fa-

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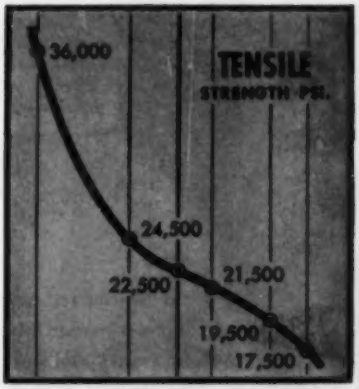

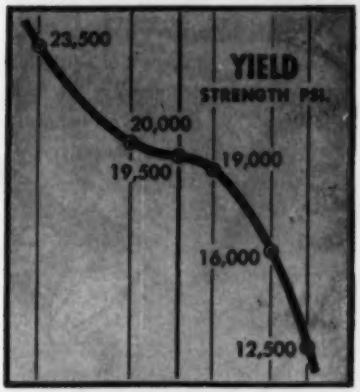

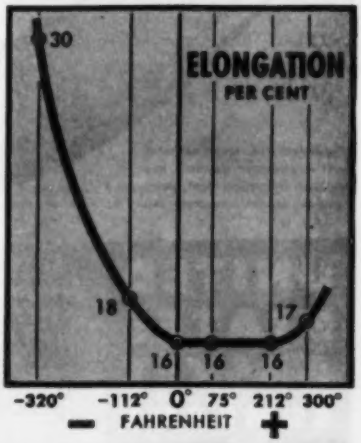

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- Furfural
- Heptaldehyde
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- Stearic, Palmitic, Maleic Oleic acids
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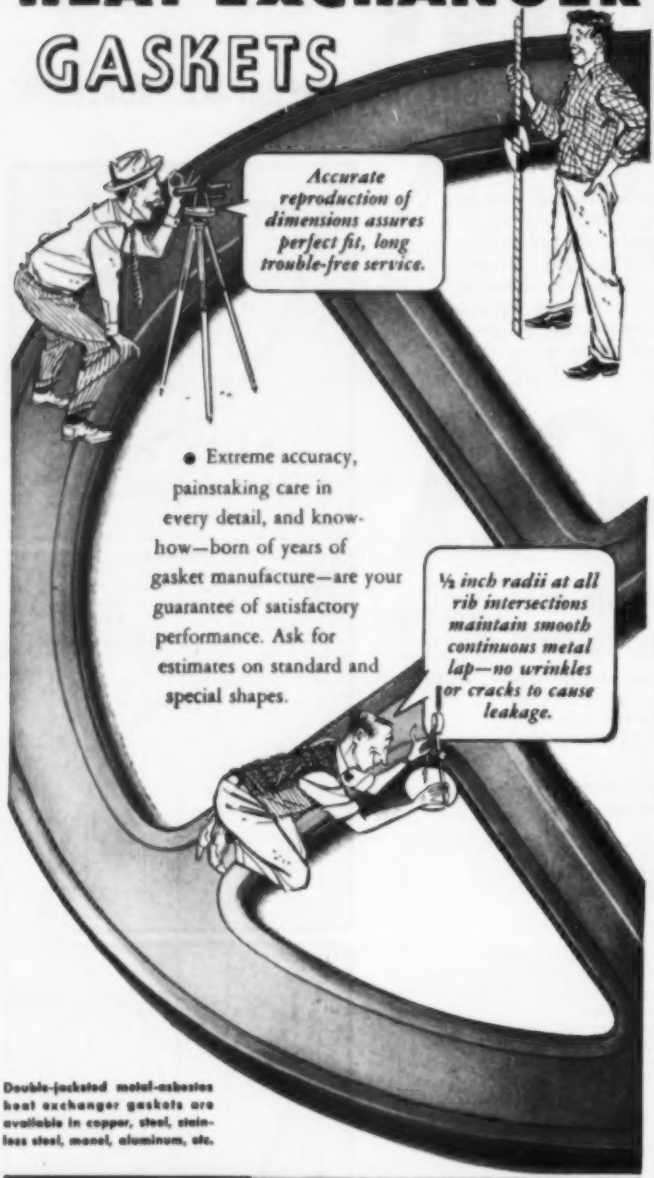
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vored. It is therefore believed that it is reasonable to seek an electronic explanation. The relatively small difference between the amounts of methane and ethane formed compared to the large drop in the proportion of propane and higher paraffins suggests the possibility of the kind of electronic effects in which methyl or ethyl groups may have greater facility for capturing a hydrogen atom than a propyl or higher alkyl group possesses.

The Distribution of Liquid and Solid Fischer-Tropsch Hydrocarbons by Carbon Number, MILTON MANES (Synthetic Fuels Research Branch, Bureau of Mines, Bruceton, Pa.), *Jour. Am. Chem. Soc.* **74** (1952), pp. 3148-51.

An equation is given for calculating the distribution by carbon number of the Fischer-Tropsch hydrocarbons. It is assumed that chain growth proceeds by stepwise addition of single carbon atoms, and further, that the probability of growth of a given hydrocarbon chain is independent of the number of carbon atoms above C_5. The equation gives the relationship of the distribution of liquid and solid products to the probability of growth, α. When the equation is applied to data from various sources it indicates the approximate constancy of α for liquid hydrocarbons, and also for waxes. Thus α is a convenient parameter for characterizing the distribution of components in the product. The constant α, of course, may vary with experimental conditions.

Manufacture: Processes and Plant

Gas-Solid Film Coefficients of Heat Transfer in Fluidized Coal Beds, J. S. WALTON, R. L. OLSON, AND OCTAVE LEVENSPIEL (Chemical Engineering Department, Oregon State College, Corvallis, Ore.), *Ind. Eng. Chem.* **44** (1952), pp. 1474-80.

The paper describes work done in determining film coefficients of heat transfer between gas and solid particles in beds of fluidized solids. Twelve runs were made using finely crushed Utah coal fluidized with heated air. The film coefficient of heat transfer between gas and solid was determined with sufficient accuracy for most engineering purposes. Maximum and minimum possible coefficients, based on measurable temperature limits of the solid, are believed to closely bracket the true value. Particle size ranges were limited to between 20- and 48-mesh, because of solid leakage for the finer particles and channeling for the larger sizes. Mass velocities varied from 325 pounds per hour per square foot, which ensured fluidization, to 920 pounds per hour per square foot, the maximum that was practical for the apparatus used. Coefficients increased with increasing mass velocity and increasing particle size. An equation is given correlating the functions of mass velocity and average particle size. The method used for determining surface areas of crushed, sized, and irregularly shaped solids is also described. A bibliography of 19 references is included.

Mass-Transfer Rate in Packed Columns. Its Analogy to Pressure Loss, SABRI ERGUN (Carnegie Institute of Tech-

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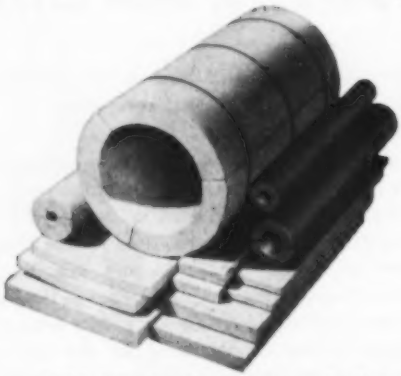

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nology, Pittsburgh, Pennsylvania), *Chem. Eng. Progress* **48** (1952), pp. 227-36.

The coefficient of mass transfer in fixed beds is shown to be a linear function of the fluid flow rate in terms of quantities that are specific functions of fractional void volume, particle size, fluid viscosity and density, and the coefficient of diffusion. An equation is given that expresses the analogy of mass-transfer rates to pressure loss in packed systems, and, based upon this analogy, equations are developed that permit evaluation of mass-transfer rates independently of pressure drop. Relatively simple equations are presented for the mass-transfer factor, the mass-transfer coefficient and the fractional recovery of solutes for isothermal systems or systems to which an average effective temperature can be assigned. The existence of a one to one correspondence between the new mass-transfer factor and the new friction factor, introduced earlier for pressure drop in packed columns, is shown. The various relationships developed were tried and tested in terms of published data and their applicability is thus demonstrated. The results of the work are presented in some detail in graphical form and a bibliography of 22 references is included.

Effect of Holdup-Charge Ratio in Laboratory Ternary Batch Distillation, Arthur Rose and Victor J. O'Brien, Jr. (The Pennsylvania State College, State College, Pa.), *Ind. Eng. Chem.* **44** (1952), pp. 1480-6.

The purpose of the work was to obtain experimental data showing the effect of the more important variables in ternary batch distillation and to review and study various methods of calculating the course of such distillations. Also it was desired to determine whether the generalizations pertaining to binary mixtures are applicable to multicomponent systems. The system studied was n-heptane-methylcyclohexane-toluene. The column was 0.5 in. diameter, packed for five feet with 1/16-inch 36-gage helices. It had approximately 80 plates and 60-ml. holdup at a throughput of 400 ml. per hour. The holdup-charge ratio was varied by using different quantities of charge. Two ternary charge compositions were used and the reflux ratio was varied from 7.5 to 60 to 1. The general effects of holdup in ternary batch distillation were found to be the same as for binary systems. The effect of increasing percent of holdup was found to be beneficial, detrimental, or of no effect upon sharpness of separation depending upon the reflux ratio. Holdup was beneficial at reflux ratios of 7.5 and 15 to 1, but detrimental at a reflux ratio of 60 to 1, and had no effect when the reflux ratio was 30 to 1. Because two components may comprise a small part of a multicomponent solution, large effective holdup and therefore large effect on separation can be expected in multicomponent batch distillation, even though the holdup is small compared to the total charge. The data are presented in considerable detail largely in graphical form. A bibliography of eight references is included.

Theory of Bubble Formation in Liquids, Louis Bernath (E. I. du Pont de Nemours & Co., Inc., Schenectady, N. Y.),

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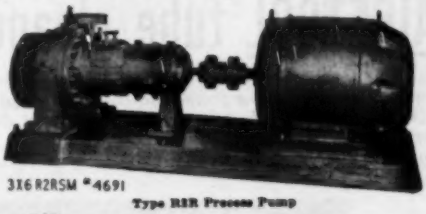

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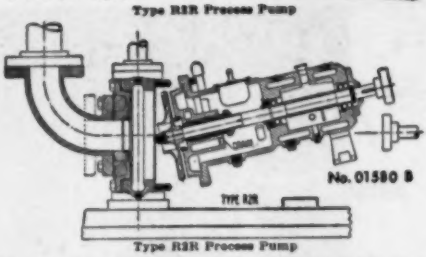

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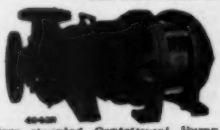

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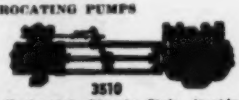

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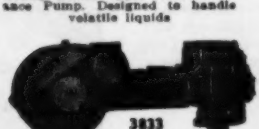

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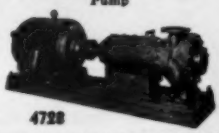

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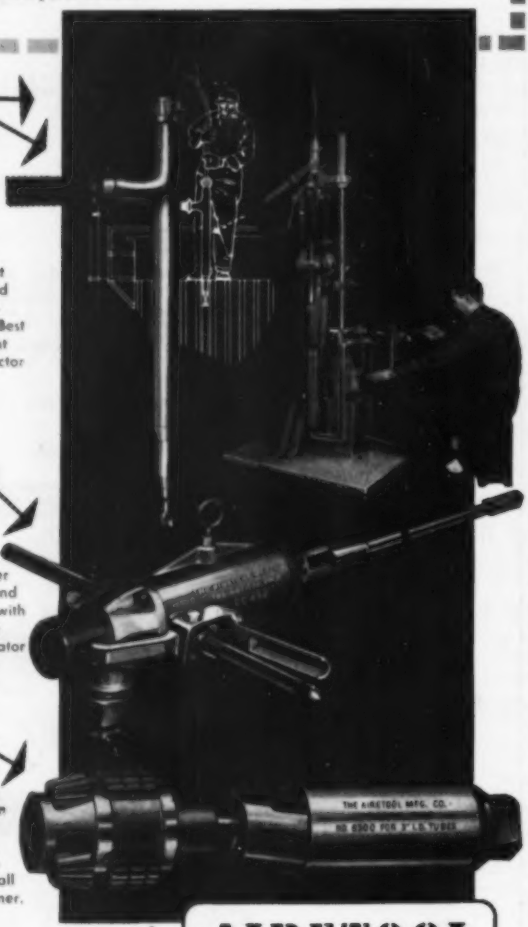

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Science and Technology

Ind. Eng. Chem. **44** (1952), pp. 1310-13.

A bubble is formed in a liquid by the vaporization of molecules of the liquid into a cavity, which can be considered as any space within the liquid phase unoccupied by liquid molecules, whether empty or occupied by vapor. When the boiling temperature is higher than that of the boiling point at normal pressure, the process is called superheating, and when it occurs at negative pressure, cavitation results. The author reviews the nucleation theory of Volmer, Becker, and Doring, as applied to the formation of vapor bubbles in pure liquids. This is followed by an application of the theory to the calculation of the fracture pressures of pure liquids. Using experimental data from the literature the actual and calculated values are compared. Results of the comparison are shown in graphical form and the agreement between theory and data is found to be good. A bibliography of seven references is included.

Multicomponent Distillation. III-Equations in Product Form and Simplified Application, P. G. Murdoch and C. D. Holland (Agricultural and Mechanical College of Texas, College Station, Texas), *Chem. Eng. Progress* **48** (1952), pp. 254-60.

In previous papers the authors presented algebraic equations for multicomponent distillations in which volatility ratios and the molal vapor and liquid flows within each section of the column are constant. The purpose of the present paper is to present a simpler method of representing the equations for any thermal condition of the column feed, and to restate the latter equation in the form of a ratio of products of factors. Equations are given for the location of the optimum feed plate in a doublet separation in which relative volatilities and molal liquid and vapor flows are constant throughout the column. The solution is simplified further by an approximation which is equivalent to reducing the system to a binary. Typical examples are given and it is indicated that the equations give solutions of sufficient accuracy unless the key components comprise only a small fraction of the feed. The time required for calculations by the approximate method is much less than that needed for use of the equations previously presented. A bibliography of 12 references is included.

Extraction of Mercaptans from Light Distillate Fuels, R. L. Yahnke, J. H. Krause, and G. H. Weisemann (Research Department, Standard Oil Co. (Indiana), Whiting, Ind.), *Ind. Eng. Chem.* **44** (1952), pp. 1486-9.

Virgin light distillate fuel obtained from high-sulfur crudes has a high mercaptan content and therefore an unpleasant odor. Such oil boils in the range 330° to 580° F. and may contain approximately 0.08 percent mercaptan sulfur. The investigation reported led to a feasible commercial process for the removal of mercaptans from light distillate fuels without degradation of the color. A solvent extraction process was used. The solvent was composed of aqueous potassium hydroxide, methanol, and potassium cresylates. The extraction is more effective at low operating temperature. It is

for producing life-saving Bacitracin

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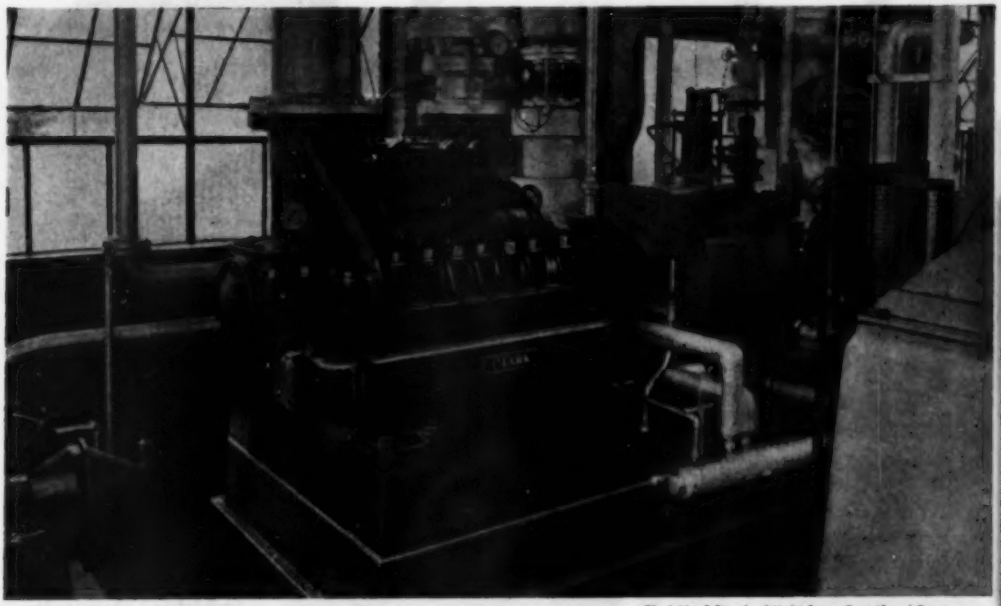

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improved by the use of concentrated potassium hydroxide as a component of the solvent, and by recycle of the by-product cresylates. In the pilot plant work, 89 percent of the mercaptans present were removed by two-stage countercurrent extraction. It was found that the extraction efficiency of the solvent after many regenerations was equal to that of the fresh solvent. Plant operating conditions would vary with the stock to be treated, the level of mercaptan removal desired, the availability of other sweetening processes, and perhaps other economic considerations. A bibliography of three references is given.

Friction and Transfer Coefficients For Single Particles and Packed Beds, W. E. RANZ (University of Illinois, Urbana, Ill.), *Chem. Eng. Progress* **48** (1952), pp. 247-53.

The properties of interest are pressure drop, transfer rates between particle and fluid, and lateral transfer caused by fluid motion. The author contends that the properties of a packed bed should submit to an analysis based on the properties of a single particle and the configuration in which it exists. A method of analysis based on the properties of a single particle is developed for estimating and characterizing the transfer rates and pressure drops in packed beds. Transfer rates and friction factors for spheres are related through the application of a simple model to heat- and mass-transfer rates and pressure drops in beds packed with spherical particles. Equations are derived for determining thermal conductivity and diffusivity, and the parametric constants that relate actual fluid velocity and average lateral velocity to superficial velocity are shown to characterize the performance of a packed bed. The method of analysis shows the mechanism by which energy is lost and transfer occurs. It should have application in the design and evaluation of any transfer device that is an assemblage of a large number of simply shaped interfaces arranged in an ordered or random pattern. A bibliography of 23 references is included.

Gaseous Fluidization of Solid Particles, ROBERT D. TOOMEY AND H. F. JOHNSTONE (University of Illinois, Urbana, Illinois), *Chem. Eng. Progress* **48** (1952), pp. 220-6.

The authors note that a review of the literature of the subject shows that there is no satisfactory explanation of the mechanism of fluidization which is quantitatively supported by the available data. The work reported was undertaken to study the motion within a fluidized system and also the rate of heat transfer between the bed and the boundary surfaces. The present article is concerned with the theory of fluidization. Data on heat transfer and an analysis of flow patterns will follow in a later paper. In the analysis of the fluidized bed, the system is assumed to attain the most stable configuration, and the particles are shown to be at their terminal velocities. The average Reynolds number in the dense or continuous phase is thus essentially independent of the superficial gas velocity. An analysis from the energy standpoint results in a general equation that relates the pressure drop to the superficial gas velocity and particle di-

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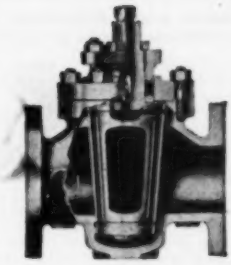

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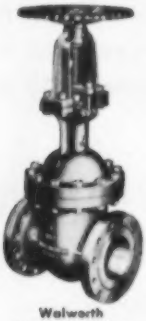

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ameter. Gas flow through the interstices of the bed at incipient fluidization and also at higher velocities can be estimated. Measurements were made at differential pressure losses through fluidized beds of spherical beads, and the velocities of particles along the wall were also measured. A bibliography of 17 references is included.

Pressure Loss In Centrifugal Entrainment Separators Under Vacuum, E. A. LAWRENCE (Colgate-Palmolive-Peet Company, Jersey City, New Jersey), *Chem. Eng. Progress* **48** (1952), pp. 241-6.

The results of an experimental study of the pressure drop through centrifugal entrainment separators operating under vacuum are presented. The work was done on fatty acid vapor, and water and glycerine vapors, but the results should be more generally applicable. Data were taken on 1-, 2- and 3-inch diameter inlet with 3-, 6- and 9-inch diameter shell and at velocities in the range 1 to 200 ft./sec. Pressure losses on 16- and 20-inch units used on large equipment are also included in order to extend the range of the study. It was found that units with tangential inlet and straight-through flow to the exit gave only about half as much resistance to flow as did those units incorporating a 180°-reversal similar to the cyclone dust collector. The author states that the pressure vs. flow calculation method of C. E. Lapple is applicable to these high velocity, high pressure drop separators. A bibliography of five references is included.

Vacuum Distillation. Variables in Packed Column Distillation at Subatmospheric Pressures, MAX S. PETERS AND M. R. CANNON (The Pennsylvania State College, State College, Pa.), *Ind. Eng. Chem.* **44** (1952), pp. 1452-9.

The purpose of the investigation was to determine the effect of reduced pressure on the separating efficiency, pressure drop, and maximum allowable velocity in packed distillation columns. The experimental work was done using a 2-inch diameter column that functioned substantially adiabatically. The authors review previous work in this field and note that the results have been contradictory. It is believed, however, that the work reported in this paper explains the contraditions and also gives several new concepts. It was found that the efficiencies of Cannon protruded and McMahon packings increased as the operating pressure was reduced, while the efficiency of Berl saddles was not appreciably affected by change in operating pressure. When efficiencies were compared at a constant boilup rate of three liters per hour, maximum efficiency was found at operating pressures between 50 and 100 mm. of mercury. When the comparison was made at 85 percent of the maximum allowable liquid velocity, the efficiencies increased as the operating pressure was changed from 735 to 10 mm. of mercury, and no maximum value was observed. The pressure drop per unit of packed height and also per theoretical plate at constant boilup rate increased for all packings tested as the operating pressure was reduced. Two new methods for predicting maximum mass velocity are presented. These are easy to apply and are accurate. A critical reflux ratio was found, below which the separating effi-

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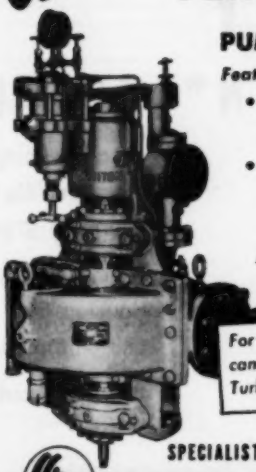

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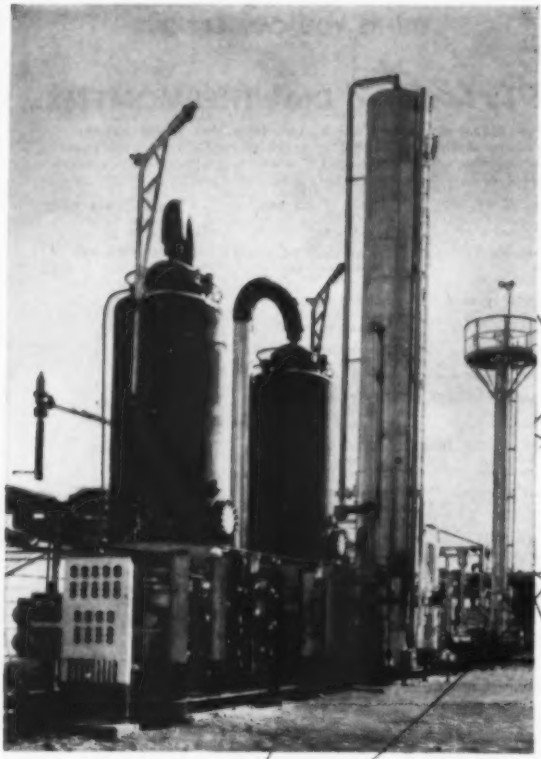

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ciencies of the packings fell rapidly. This critical value was found to apply at operating pressures between 10 and 735 mm. of mercury. The data are presented in considerable detail in tabular and graphical form and a bibliography of 10 references is included.

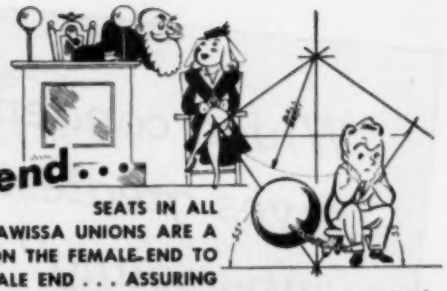
Products: Properties, Utilization and Analysis

Tapered-Hole Disk Penetrometer for Determining Consistency of Semifluid Greases, D. H. Birdsall and B. W. Hotten (California Research Corporation, Richmond, Calif.), *Analytical Chem.* **24** (1952), pp. 892-894.

Semifluid greases have consistencies between lubricating oils and consistent greases. They contain thickeners in concentrations of 1 to 9 percent, and are too viscous to be measured by normal viscometric means and yet too fluid to be graded by conventional penetration procedures. Their structure is so fragile that measurements at low shear rates are required if the consistency of the thickener-oil system rather than the viscosity of the base oil is to be measured. The authors describe a tapered-hole disk penetrometer which provides a satisfactory method for the grading of these semifluid greases. A summary is given of present methods for determining the consistency of these semifluid greases and the advantages and disadvantages of these methods are noted. The new disk-type penetrometers with tapered holes is used in conjunction with the ASTM penetrometer, and its use requires no special skill or training other than that normally required for the operation of the ASTM penetrometer. Typical results are given and compared with the results obtained by previously used methods and equipment.

The Influence of Soap-Phase Structure on Some Physical Properties of Lithium Greases, D. Evans, J. F. Hurron and J. B. Matthews (Thornton Research Center, P. O. Box No. 1, Chester, England), *Jour. of Applied Chem.* **2** (1952), pp. 252-62.

Although thermal analysis techniques have been successfully applied to soaps to determine the temperatures at which phase transformations occur, no attempt has apparently been made to determine the relationship between the phase transformations that occur in soap-oil systems, such as conventional lubricating greases. However, these changes play a significant part in determining the final properties of the greases. The authors describe a calorimetric technique for measuring the temperatures and latent heats of phase transformation in greases made from hydrocarbon oils and lithium soaps. The lithium soaps were composed of lithium stearate and lithium 12-hydroxystearate. Lithium greases were prepared, varying the temperature conditions during their preparation so that the soap fibres present in the final greases were grown while the system existed in different phase structures. The hardness and resistance to oil separation were found to be determined by the soap phase existing during the growth of the fibres. Wide variations in properties can be obtained by control of the conditions. Photomicrographs and electron-micrographs are given that show fibre aggregation, fibre growth, etc.



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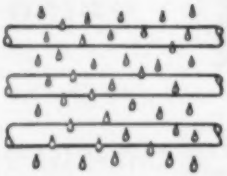
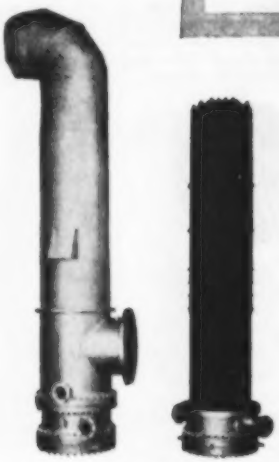
B

Diagram of one of the finned elements of a G-R G-Fin Vertical Condenser. Here, the drops of condensate are guided along the channels formed by each of the G-Fins, so that they are in constant contact with the tubes throughout their entire downward flow.



A

Diagram of part of a standard horizontal tubular condenser. Here, the drops of condensate hop, skip and jump down over the bare tubes, with only momentary contact at each tube.



These two diagrams show why the G-R G-Fin Vertical Condenser provides far greater sub-cooling effect than horizontal bare tube units for condensing hydrocarbon vapors.

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Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

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(From the Official Gazette, June 3, 10, 17 and 24, 1952)

REFINING

U.S.P. 2,598,725. Prevention of Corrosion. D. B. Sheldahl to Sinclair Refining Company.

Light petroleum distillate fractions are incorporated with 0.6 to 4.0 pounds of ammonium mahogany sulfonates on the oil-free basis and 0.4 to 4.0 pounds of morpholine, each per 1000 barrels of petroleum distillate. The additives impart anticorrosive properties to the distillate.

U.S.P. 2,598,785. Treatment of Gaseous Hydrocarbon Material Streams. J. L. Groebe and J. T. Karbosky to Phillips Petroleum Company.

A gaseous mixture containing nitrogen and methane is subjected to a fractional separation in a low-temperature fractional distillation zone. An overhead stream of nitrogen and methane in equilibrium with a methane rich stream are produced. The methane rich stream is used to reflux the low-temperature distillation zone. The overhead nitrogen and methane stream are separated in a selective adsorption zone.

U.S.P. 2,598,840. Heater for Hydrocarbon Fluid. A. H. Schutte to The Lummus Company.

The construction is claimed of a heater for a hydrocarbon liquid.

U.S.P. 2,599,338. Motor Fuel. W. E. Lifson and G. W. Duncan to Standard Oil Development Company.

A hydrocarbon fuel mixture boiling in the gasoline range or a motor fuel with an octane number above 80 contains .05 to 1 percent of a furfuryl alcohol, such as tetrahydro furfuryl alcohol. The operating conditions of the fuel are improved by the addition.

U.S.P. 2,599,341. New Phosphorus Containing Compounds. J. P. McDermott to Standard Oil Development Company.

A hydrocarbon oil has incorporated therein a compound of the formula

$P = X_n$

wherein R is an alkyl group with 3 to 8 C atoms, X is oxygen or sulfur, n is 0 or 1, and m is an odd number from 3 to 5, but is 3 when n is 1. The additive has corrosion inhibiting properties.

U.S.P. 2,599,538. Process of Demulsifying. C. M. Blair, Jr., to Petrolite Corporation, Ltd.

A water-in-oil type emulsion is broken by a demulsifier including an organic polyester of a dibasic acid and an aliphatic glycol having not more than 6 C atoms and having the C atoms joined together by C to C linkages, the acid being a dicarboxylic acid with less than 8 C atoms.

U.S.P. 2,599,545. Cyclic Adsorption Process. C. J. Egan and J. W. Scott to California Research Corporation.

A cyclic adsorption process is described which provides a practicable process for the separation of liquid mixtures by preferential adsorption wherein the difficulties which attend the employment of a moving mass of adsorbent particles are avoided and in which the adsorbent particles employed may be substantially smaller. A method for the recovery of adsorbate and reactivation of the adsorbent is also provided wherein the inventory of adsorbent and the volume of material to be treated in secondary recovery processes is substantially smaller than if batch operations were employed.

U.S.P. 2,599,752. Drilling Fluids. P. W. Fisher to Union Oil Company of California.

A drilling fluid consists of a mineral oil base containing 1 to 10 percent by weight of solid $CaCl_2$ and 0.2 to 10 percent of a mixture of alkali-metal and calcium rosin acid soaps or other alkaline earth metal salts and oil soluble soap disperging agents.

U.S.P. 2,600,106. Removal of Diolefin Polymers from Extractive Distillation Solvent. B. S. Garrett to Standard Oil Development Company.

In an extractive distillation separation of hydrocarbons including cyclopentadiene in the presence of a glycol, furfural or acetone, the extracted hydrocarbons are stripped from the solvent under pressure at temperatures at which cyclopentadiene becomes dimerized in the resulting lean solvent; this solvent containing the cyclopentadiene dimer is contacted with adsorbent clay which adsorbs the dimer.

U.S.P. 2,600,110. Fractional Distillation Method. K. H. Hachmuth to Phillips Petroleum Company.

Details are claimed of an internal-refrigerant low-temperature fractional distillation process for separating a multi-component mixture of vaporizable material, preferably such of low-boiling, normally gaseous hydrocarbons, wherein the lowest boiling components, e.g. ethylene and/or ethane, are used as the internal-refrigerant.

U.S.P. 2,600,113. Motor Fuel. A. R. Jones and J. O. Smith, Jr., to Standard Oil Development Co.

A mixture of hydrocarbons boiling in the gasoline range contains .05 to 1 percent by volume of an aliphatic thioether of a monocarboxylic acid of the formula: $C_xH_{2x+1}—S—(CH_2)_y$ COOH, wherein x is an integer 8-25 and y is 1-3. Lauryl mercaptoacetic acid is an example of such acid. Stalling of internal combustion engines under idling conditions and the like may be overcome by the additive.

U.S.P. 2,600,133. Maintaining BTU Content of Residue Gas from Absorber. R. K. Simms to Phillips Petroleum Company.

A process for treating a gaseous mixture comprising C_1 to C_5 hydrocarbons is described in which fractionation is obtained by absorbing the hydrocarbons in a lean absorption oil at high pressure and desorbing them stepwise at lower, controlled pressures. Further control is obtained by employment of a continuous moving bed activated charcoal adsorber to treat the product desorbed from the absorption oil.

U.S.P. 2,600,154. Antioxidant. W. H. Brugmann, Jr., to Standard Oil Development Company.

A petroleum hydrocarbon product contains 0.01 to 10 percent by weight of a reaction product obtained by heating under special conditions a phenol with phosphorus sulfochloride and reacting the product obtained with certain amounts of a metal salt of the formula: $(RX)_n—PS—SM$ where R is a hydrocarbon radical with 2-30 C atoms, X is oxygen or sulfur, and M represents the hydrogen equivalent of an alkali or alkaline earth metal. The additive inhibits oxidation.

U.S.P. 2,600,158. Process for Hydrocarbon Gas Mixture Analysis. A. T. Clothier to Standard Oil Development Company.

Details are claimed of a process for analyzing a gas mixture for its content of hydrocarbons of 2-5 C atoms wherein such hydrocarbons are present in minute quantities in admixture with methane and with relatively large quantities of oxygen and nitrogen.

U.S.P. 2,600,182. Refining Kerosenes and Gas Oil by Ternary Azeotropic Distillation with Furfural and Water. G.

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B. Arnold and L. Kovach to The Texas Company.

A feed oil of the class of kerosene and gas oil containing paraffinic and non-paraffinic constituents is refined to separate therefrom by azeotropic distillation in the presence of water and a polar solvent comprising furfural, a fraction enriched in paraffinic constituents. Details are claimed.

U.S.P. 2,600,184. Refining Kerosenes and Gas Oil by Ternary Azeotropic Distillation. G. B. Arnold and L. Kovach to The Texas Company.

The process of this patent is related to that of **U.S.P. 2,600,182.** Phenol or aniline are here used as the polar solvent.

U.S.P. 2,600,389. Three-Stage Propane Fractionation of Reduced Crude Oil. B. C. Benedict to Phillips Petroleum Company.

Details are claimed of a process for fractionating an asphalt-containing crude lubricating oil stock with liquid propane in order to separate lubricating oil fractions.

U.S.P. 2,600,494. Low-Temperature Separation Process. B. J. Ferro, Jr., to Phillips Petroleum Company.

Nitrogen is separated from an admixture with higher boiling normally gaseous constituents, e.g. from natural gas, by a low-temperature process under superatmospheric pressure. Details of the process are claimed.

U.S.P. 2,600,537. Recovery of Deashed Oil and Naphthenic Acids from Residuum Stocks. E. M. Honeycutt to Sun Oil Company.

Residuum charge oil containing alkali metal naphthenates is intimately mixed with aqueous propyl alcohol in an amount sufficient to dissolve at least most of the naphthenates and with at least an equal volume of C_7-C_8 saturated hydrocarbons. An alcohol phase is separated by settling above 80°F. from an oil phase. On vaporizing solvent from the oil phase, deashed oil is obtained. The alcohol phase is further treated to obtain purified, naphthenic acids.

U.S.P. 2,600,671. Hydrofluoric Acid Refining of Hydrocarbon Oils. S. Miron to Pan American Refining Corporation.

Tar-containing mineral oils are intimately contacted with at least 1/10 part by weight of liquid HF at a temperature of 375-450°F. under sufficient pressure to maintain the HF in liquid state. The resulting mixture is separated at this temperature by differences of density into three phases, a tar phase, an oil phase, and a HF phase.

U.S.P. 2,601,009. Method of Low-Temperature Separation of Gases into Constituents. J. S. Swearingen to Institute of Inventive Research, San Antonio, Texas.

Details are claimed of a method for separating a gaseous hydrocarbon mixture into its heavier and lighter constituents by low-temperature fractionation.

U.S.P. 2,601,050. Drilling Fluid. A. C. Nestle to Texaco Development Corporation.

A drilling fluid contains mineral oil and finely divided constituents of certain tree barks.

U.S.P. 2,601,077. Distillation of Light Hydrocarbons. R. Wylie to Standard Oil Development Company.

A method is claimed for distilling low boiling normally gaseous hydrocarbons from a feed mixture including at least three hydrocarbons of different boiling points.

U.S.P. 2,601,257. Continuous Process for Thermal Extraction of Oil Shale. F. E. Buchan to the U. S. Secretary of the Interior.

Shale oil is continuously extracted from oil shale, using a heavy shale oil fraction previously obtained in the process as the liquid extracting solvent, maintaining a temperature of 700-800°F. in the extraction zone, whereby the kerogen content of the shale is converted into products soluble in said oil, and maintaining the pressure in this zone substantially above atmospheric to prevent excessive volatilization of the extracting oil and the extracted products. More details are claimed.

U.S.P. 2,601,298. Cooling Gases Containing Condensible Material. P. C. Keith to Hydrocarbon Research, Inc.

Adsorptive particles are brought into contact with the cooling surfaces of a heat exchanger to adsorb preferentially the condensible matter of the gaseous stream undergoing cooling in order to prevent the accumulation of condensed material on the cooling surfaces. Adsorptive particles are periodically or

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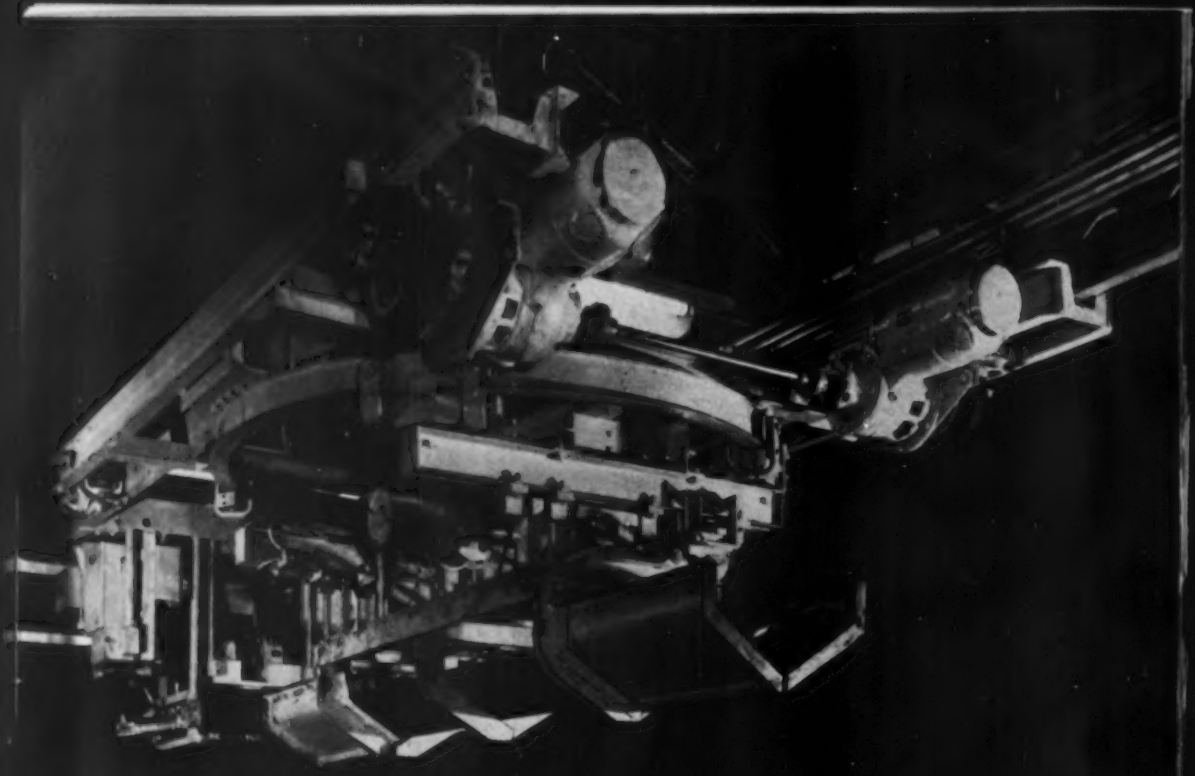

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U.S.P. 2,601,599. Method of Recovering Liquefiable Hydrocarbons from Gases. P. H. Deming to Shell Development Company.

Liquefiable hydrocarbons are recovered from wet hydrocarbon gas consisting predominantly of hydrocarbons with less than 3 C atoms and lesser amounts of the liquefiable hydrocarbons, such as a well fluid. The wet gas is cooled at a pressure above its bubble point pressure and is then expanded under conditions such that a dry gas and a liquid containing the liquefiable hydrocarbons are formed.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,599,449. Method of Reactivating Alkali Solutions Used in Treatment of Hydrocarbon Oils. J. Happel and S. P. Cauley to Socony-Vacuum Oil Co., Inc.

Alkali solution used to extract weakly acidic sulfur compounds, such as mercaptans, from hydrocarbon oil is reactivated by contact with a gas containing free oxygen in the presence of an aromatic substance containing only three hydroxyl groups attached to three adjacent positions of a single benzene ring.

U.S.P. 2,599,978. Process of Plating Carrier Particles with a Catalytic Metal. O. F. Davis and H. Nack to The Commonwealth Engineering Company of Ohio.

Catalyst core particles are heated in a closure to a temperature sufficient to decompose heat-decomposable metal vapors in contact therewith. Details of the process are claimed for plating the cores with catalytic metal.

U.S.P. 2,600,360. Suppressing the Oxidation of CO to CO_2 in a Fixed Bed Regenerator. A. V. Grosse.

The oxidation of carbon on spent catalysts is limited to the formation of CO rather than CO_2 by use of an inhibitor. This greatly reduces the evolution of heat during regeneration. Chlorides and bromides of silicon and to a lesser extent of Al, Ti, and Fr mixed together with free chlorine or bromine are effective in suppressing the formation of CO_2. About five percent by volume of the suppressor mixture in oxygen containing gas is contacted with the carbonized catalyst at a rate of about 40 volumes of gas per volume of catalyst per hour. At least 60 percent of the carbon oxides formed is CO.

U.S.P. 2,600,379. Supported Group VIII-Carbon Dehydrogenation Catalyst. T. F. Doumani and R. F. Deering to Union Oil Company of California.

A catalyst for the dehydrogenation of ethylbenzene is described which is prepared by impregnating an inert carrier such as silica or alumina with an aqueous solution of a salt of a group VIII metal, decomposing the salt to oxide, reducing and passing ethylene over this mass at about 600°C. and atmospheric pressure to deposit carbonaceous material. The

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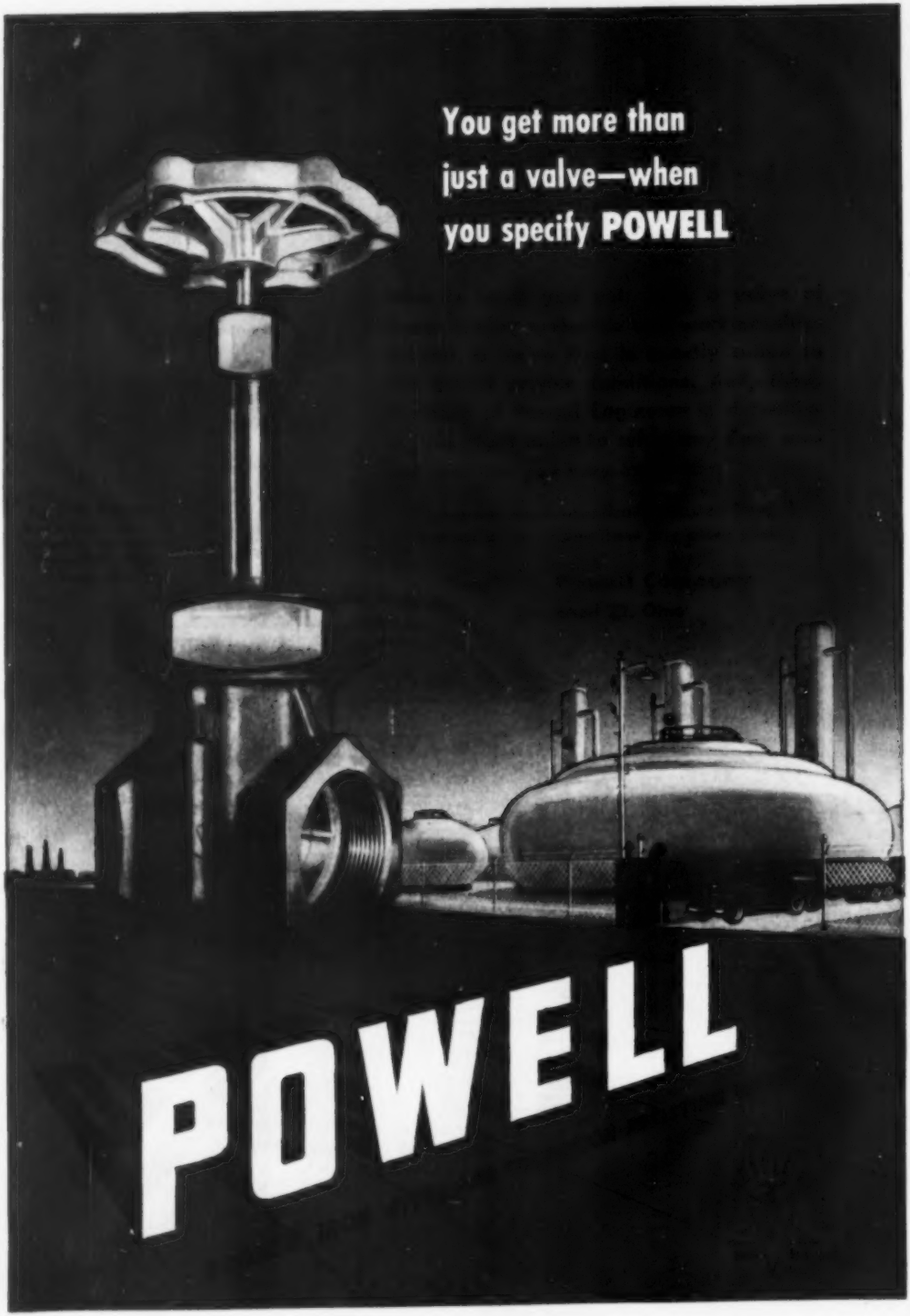
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U.S.P. 2,600,654. Chromium Oxide-Cadmium Chloride-Cadmium Oxide Catalyst. E. C. Jacobs and L. G. Lundsted to Wyandotte Chemical Corporation.

A catalyst composition of a washed and dried aqueous ammoniacal gel comprises a mixture of Cr_2O_3, $CdCl_2$ and CdO in certain proportions.

U.S.P. 2,600,655. Chromium Oxide-Tungsten Oxide-Iron Oxide Gel Catalyst. E. C. Jacobs and L. G. Lundsted to Wyandotte Chemicals Corporation.

A catalyst for the aldehydoisomerization of alkylene alpha oxides consists of a washed and dried gel mixture containing 13.2 to 51 mole per cent chromia, 3.8 to 33.3 percent tungsten oxide and one mole per cent iron oxide.

U.S.P. 2,601,121. Preconditioning Hydrocarbon Synthesis Catalyst and Removing Fines Therefrom. W. J. Mattox to Standard Oil Development Company.

An iron catalyst in powdered form is preconditioned to adapt it for fluidization in a hydrocarbon synthesis. This is done by subjecting a fluidized bed of the catalyst to the influence of a H_2/CO mixture containing one to five moles of H_2 per mole of CO at a temperature of 500-900° F. to convert a substantial proportion of the iron to its carbide. Fines formed in this treatment are eliminated.

U.S.P. 2,601,291. Nonfreezing Silica Sols stabilized with Organic Amine Compounds. S. C. Horning and C. W. Shay to E. I. du Pont de Nemours & Co., Inc.

A silica sol is stabilized against the effects of freezing by dissolving in the sol between 0.05 and 2.2 moles per 100 g. of SiO_2 of a water soluble organic amine having no chain of more than six carbon atoms, the amine being selected from the group consisting of acyclic and alicyclic, non-aromatic amines. The stabilized sol can be frozen and thawed repeatedly with but little damage to the sol.

U.S.P. 2,601,624. Coprecipitated Alumina-Metal Oxide Gel Catalysts and Their Preparation. J. R. Owen and J. W. Myers to Phillips Petroleum Company.

A pelleted gel catalyst consisting of alumina and at least one of the oxides of Cr, V, Be is impregnated with a solution of a compound of one of these metals. The impregnated pellets are calcined to effect conversion of this compound to the oxide and to increase the crushing strength of the catalyst pellets.

CRACKING AND REFORMING

U.S.P. 2,599,197. Control System for Catalytic Reactors. N. F. Prescott to Atwood & Morrill Company.

The construction is claimed of an apparatus for use in effecting catalytic reactions, particularly cracking, in the presence of a fluidized catalyst using air as fluidizing medium.

U.S.P. 2,600,430. Conversion of Carbonaceous Material. E. W. Riblett to Hydrocarbon Research, Inc.

The invention concerns the carbonization of carbonaceous material, gasification of coke, and cracking of oil in a fluidized system, whereby the necessary flow of heat from the gasifier to the carbonizer and the cracking unit is materially facilitated and improved.

POLYMERIZATION AND CONVERSION

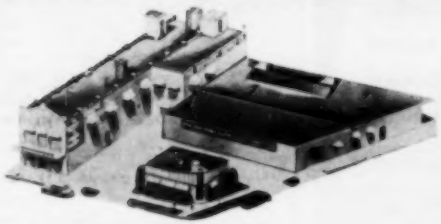
U.S.P. 2,599,249. Method of Copolymerizing Ethylene with Butadiene. B. S. Friedman to Sinclair Refining Company.

Liquid, higher mole weight, straight-chain diolefin copolymers with 6 to 10 C atoms are formed by reacting ethylene with butadiene in the presence of Co_2O_3-charcoal catalyst at a temperature of 165-575°F., a pressure of 100-1000 psi., and a reaction space velocity of 25-400 volumes of each of the fluid reactants per volume of catalyst per hour.

U.S.P. 2,599,568. Gas Disengaging Combination for Catalytic Contacting Apparatus. D. D. McKinney to Houdry Process Corporation.

The construction is claimed of a gas-solid contacting apparatus having a vertical housing traversed concurrently by gravitating contact material and hydrocarbon vapors. The reacted vapors and entrained fines are disengaged from the gravitating material in a lower zone

Patents



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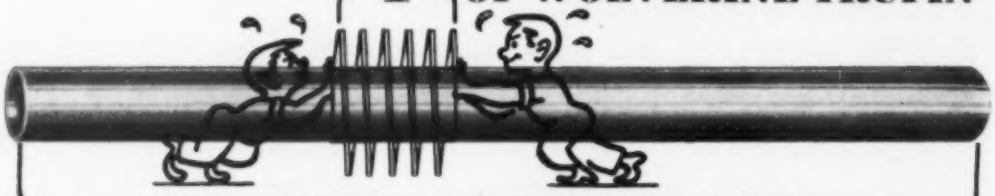

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of the housing. The reacted vapors and entrained fines are passed to a fines-accumulating chamber. A collector ring is connected with this chamber by a plurality of spaced pipes.

U.S.P. 2,599,743. Conversion of Propylene Polymers. L. F. Brooke to California Research Corporation.

An olefinic hydrocarbon material with a five percent point above 350°F. and a 90 percent point below 525°F. is produced by reacting a polymer boiling below 350°F. derived from the catalytic polymerization of propylene with liquid phosphoric acid having a concentration of 102-110 percent calculated as orthophosphoric acid. A reaction temperature below 325°F. and a space velocity in excess of 0-2 V/V/Hr are maintained.

U.S.P. 2,600,454. Resinous Materials from 1,2-Dimethylenecyclohexanes. J. E. Wicklatz and J. N. Short to Phillips Petroleum Company.

A mixture of a 1,2-dimethylenecyclohexane containing monomer and another copolymerizable monomer is catalytically polymerized. The cyclohexane compound employed shall have a specific constitution and may contain various hydrocarbon substituents besides the two methylene groups.

U.S.P. 2,600,528. Apparatus for Elevating Contact Material. E. J. Grace, Jr., to Sun Oil Company

An apparatus is claimed for elevating granular material from a lower chamber to an upper chamber. Fluid from a conduit extending through the bottom of the lower chamber and having its outlet end positioned below the lower end of the elevating conduit within the body of granular material lifts this material upward.

U.S.P. 2,600,679. Process for Copolymerizing Conjugated Dienes with Unsaturated Nitriles in Aqueous Emulsion. H. F. Park to Monsanto Chemical Company.

Sixty-five parts of butadiene are emulsion copolymerized at 30°C. with 40 parts of acrylonitrile in the presence of 0.4 parts of the sodium salt of dioctyl succinate, 0.02 parts of potassium persulfate and further small amounts of $NaHCO_3$, $NaHSO_3$ and dodecyl mercaptan.

U.S.P. 2,600,680. Process for Copolymerizing Conjugated Dienes with Unsaturated Esters in Aqueous Emulsion. H. F. Park to Monsanto Chemical Company.

The process of this patent is related to that of **U.S.P. 2,600,679.** Certain proportions of CCl_4, potassium persulfate, sodium sulfonate of dioctyl succinate, NaOH, water, isoprene and n-butyl crotonate are here heated in mixture in an autoclave of 75°C. while stirring.

U.S.P. 2,601,273. Copolymers of Cyclopentadiene. H. L. Gerhart to Pittsburg Plate Glass Company.

Five-80 percent by weight of cyclopentadiene or lower homopolymers thereof, 20-90 percent of an unsaturated glyceride oil, and 1-50 percent of a monomeric polymerizable ethylenically unsaturated compound containing a $CH_2=C<$ group are heated together to a temperature of 300-600° F. to form a copolymer.

U.S.P. 2,601,673. Shortstopping the Addition Polymerization of Unsaturated Organic Compounds. F. M. McMillan and E. T. Bishop to Shell Development Company.

In the emulsion polymerization of butadiene-1,3 and/or aryl olefin, such as styrene, an amount of 0.001-2 parts by weight of 2,2,4,6-tetramethyldihydropyridine per 100 parts of the polymerizable material is added to polymer while the emulsion still contains unreacted monomeric material. The polymerization is terminated by the additive.

U.S.P. 2,601,676. Control of Flow of Fluidized Solids. R. P. Trainer and L. E. Border to Shell Development Company.

In the conversion of hydrocarbon in the presence of fluidized solids, e.g. in a catalytic cracking operation, wherein a bed of continuously replenished fluidized solid is continuously maintained in a vessel, the rate of withdrawal of fluidized solid from the bed through an orifice of controllable areas is controlled by controlling the pressure above the fluidized bed in inverse relationship and in response to changes in the differential pressure measured across the orifice. The area of this orifice is controlled in direct relationship to and in response to changes in the differential pressure measured between the pressure above the fluidized bed and the pressure at a point within this fluidized bed.

ALKYLATION

U.S.P. 2,598,715. Separation of Naphthalene Isomers. J. E. Nickels to Koppers Company, Inc.

A mixture of alpha- and beta-alkyl isomeric naphthalenes, in which the alkyl group consists of primary or secondary alkyl groups with 1-5 C atoms, is treated with an alkylating agent containing a tertiary alkyl group having 4-6 C atoms. The alkylating agent shall be present in an amount sufficient to furnish one mole of alkylating agent per mole of beta-isomer reacted and two moles per mole of alpha-isomer reacted. The di-tertiary alkyl derivative formed from the alpha-isomer is physically separated from the mono-tertiary alkyl derivative formed from the beta-isomer. The separated derivative of the alpha-isomer is then dealkylated.

DESULFURIZATION

U.S.P. 2,600,328. Separation of Acidic Constituents from Gases. F. C. Riesenfeld and H. D. Frazier to The Fluor Corp., Ltd.

A hydrocarbon gas containing H_2S and CO_2 is treated with a monophase liquid absorbent comprising an alkanolamine, water and a compound boiling above 190°C. and consisting of a monohydric alcohol, a water-soluble ether of polyhydric alcohols, or the like. Details are claimed.

U.S.P. 2,600,931. Process for Refining High Sulfur Crude Oils. W. A. Slater to Gulf Oil Corporation.

A topped or reduced crude is con-

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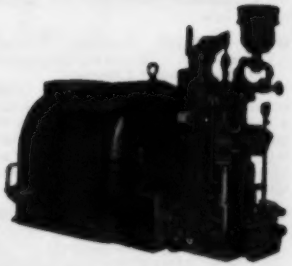

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tacted with a material consisting of iron or nickel or cobalt, their oxides and combinations at 750-950° F., 100-1500 psi. and a space rate of 0.2-6 liquid V/V/Hr in the presence of about 20,000 cft of hydrogen per barrel of oil. Sulfur in the oil is absorbed on the contact mass and the contacting is terminated before substantial amount of H_2S appear in the product. The treated product is then subjected to fractionation and/or catalytic cracking.

HEAVY OILS AND WAXES

U.S.P. 2,598,724. Method for Increasing the Melting Point of Petrolatums and Products Resulting Therefrom. L. Schmerling to Universal Oil Products Company.

The melting point of petrolatum is increased by subjecting ethylene and petrolatum to the action of an organic peroxide condensation catalyst at a temperature at least as high as the decomposition temperature of the catalyst.

U.S.P. 2,599,337. Lubricating Oil Additives. E. Lieber and E. P. Cashman to Standard Oil Development Company.

A waxy mineral lubricating oil has dissolved therein at least a pour depressing amount of a benzene sulfonyl halide derivative of a Friedel-Crafts condensation product of chlorinated paraffin wax with an aromatic compound having at least one substituent group thereon.

U.S.P. 2,599,339. Compositions Containing a Major Amount of a Wax and a Minor Amount of a Copolymer of Ethylene-1,2-Dicarboxylic Acids and Their Derivatives. S. B. Lippincott and D. W. Young to Standard Oil Development Company.

A paraffin wax contains a minor proportion (for example, 0.1-1 percent) of a completely esterfied aliphatic ester of an alkene-maleic anhydride copolymer wherein the esterification agent is a monohydric saturated alcohol. The tensile strength of high mole weight wax is improved by the additive.

U.S.P. 2,599,343. High-Temperature Lubricating Grease Manufacture. A. J. Morway and J. J. Kolfenbach to Standard Oil Development Company.

Details are claimed for preparing a lubricating grease from certain proportions of mineral base lubricating oil, a saponifiable fatty acid having 12 to 22 C atoms and a strong metal base, and an aldehyde of mole weight less than C_{18} fatty acids and capable of undergoing the Cannizzaro reaction in the presence of said base.

U.S.P. 2,599,353. Stainless Emulsible Grease. J. C. Showalter to Standard Oil Development Company.

A stainless, emulsible grease composition comprises certain proportions of a hydrocarbon base lubricating oil containing alkali metal petroleum sulfonates, tall oil, a polyhydroxy alcohol, a corrosion inhibitor, a fatty acid, and mica or talc.

U.S.P. 2,599,683. Grease Composition. S. T. Abrams and F. H. Stross to Shell Development Company.

A major proportion of a lubricating oil is compounded with 5-40 percent by weight of an anhydrous alumina gel and 2-20 percent (of said gel) of a lipophilic acid containing at least one hydrocarbon radical with at least 10 C atoms. Phosphoric and phosphinic acids, fatty acids, aliphatic dicarboxylic acids, sulfonic acids, and the like, may be employed as the lipophilic acid.

U.S.P. 2,599,736. Lubricating Composition Containing the Reaction Product of Biuret and Aliphatic Esters of Hydroxy Acids. D. E. Adelson and R. G. Larsen to Shell Development Company.

A lubricating oil contains a minor amount of a reaction product of a biuret and aliphatic esters of hydroxy acids combined in certain proportions and under certain conditions. Wear and oxidation are inhibited by the additive.

U.S.P. 2,599,761. Extreme Pressure Lubricant. D. Harman and R. E. Thorpe to Shell Development Company.

A mineral lubricating oil contains a minor amount of a reaction product obtained from a hydrocarbyl phosphite and a hydrocarbyl polyhaloalkanephosphonate. The additive imparts extreme pressure properties to the oil.

U.S.P. 2,599,794. Lubricating Compositions. W. C. Webber to Shell Development Company.

A mineral lubricating oil contains a nitro-1,3-benzodioxane having 1-2 trichloromethyl radicals directly attached to the dioxane ring, the nitro group being attached directly to the 6-position of this ring. The additive imparts extreme pressure properties to the oil.

U.S.P. 2,600,798. Esters of Thiophene-Modified Maleic Anhydride-Styrene Copolymers and Oil Compositions Containing the Same. F. P. Otto and O. M. Reiff to Socony-Vacuum Oil Co., Inc.

A mineral lubricating oil contains a minor amount of a reaction product of maleic anhydride, styrene and a thiophene compound. The additive improves the viscosity index and depresses the pour point of the oil.

U.S.P. 2,601,109. Method of Preparing Blends of Hydrocarbon Polymers and Petroleum Waxes. J. J. Fish to Sun Chemical Corporation.

A polymerized mono-olefin, such as polyethylene, and a petroleum wax material consisting of saturated hydrocarbons are treated with BF_3 or the halides of Al, Fe, or Zn at temperatures above 200° F., but below the cracking temperature of the wax material. A stable, homogeneous, wax-like composition is obtained which shows no separation under various conditions.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Cyclobutene
Di-tert.-butyl ketone
3,4-Dinitrobenzio acid
Methylaluminum dichloride
Mucono nitrile
Ethyl-o-carbonate
4-Bromo-m-xylene
Trimethyl phosphine
Pseudopelletierine
Cyclohexylphenyl ketone
3,4-Dimethylaniline
Retene
1,11-Undecanedioic acid
ortho-Xylyl chloride
Fluoroiodomethane
N-Allylpiperidine
Ethylsulfinic acid
Isophthalaldehyde

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,600,399. Catalytic Reduction of Carbonmonoxide with Hydrogen. W. G. Frankenburg and E. T. Layng to Hydrocarbon Research, Inc.

An equation is given for the composition and conditions of a reactant gas containing more than 15 mole percent CO and less than two mole percent water vapor, which reactant gas is to be used in the hydrocarbon synthesis over an iron catalyst.

U S P. 2,600,452. Catalytic Improvement of Hydrocarbon Synthesis Product. A. Voorhies, Jr., to Standard Oil Development Company.

A synthesis product boiling in the gasoline range and containing oxygenated compounds and alfa-olefins is greatly improved in its octane number by treatment with a severely deactivated and plant contaminated silica-alumina cracking catalyst, having a D + 1. value of not substantially above 20. The treatment is carried out at 800-975° F. and a space velocity of 2 to 5 V/V/Hr.

PETROCHEMICALS

U.S.P. 2,599,350. Oxidation Inhibitor. H. W. Rudel and J. M. Boyle to Standard Oil Development Company.

A double-bonded non-aromatic hydrocarbon is reacted with a sulfur halide. The resulting addition product is reacted with an alkali metal dithiocarbamate at a temperature of 50 to 150°C., whereby the halogen of the addition product is replaced by dithiocarbamate radical. The product is useful as a oxidation inhibiting additive for mineral oils.

U.S.P. 2,599,424. Manufacture of an Acrylic Acid Ester. O. Albrecht and A. Maeder to Ciba Limited, Basel.

Acetylene is treated with nickel carbonyl under addition of an acid and a hydroxy compound containing at least one alcoholic hydroxy group and at least one C chain with at least 12 C atoms, in the presence of water and a water-insoluble aromatic or gasoline range hydrocarbon or a mixture thereof as a solvent. Acrylic acid esters are produced.

U.S.P. 2,600,444. Oxygenation of Olefins. F. W. Sullivan, Jr.

A vapor phase catalytic process is

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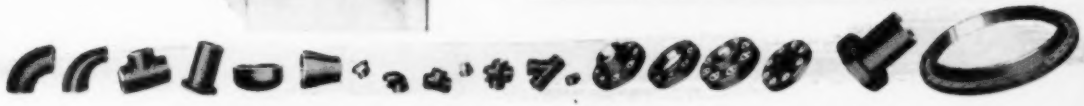

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About EQUIPMENT and SERVICE Suppliers

FOREIGN AGENTS—Filtrol Corporation, through its export manager Troy Monk and other members of the organization, welcomed representatives from more than 20 countries who were present at the second International Foreign Agents' meeting of Filtrol Corporation, held recently in Los Angeles. Stanard R. Funsten, manager of sales of Filtrol, said that in 1951 Filtrol shipped their products to 48 different foreign countries.

Worthington's Research, Development Chief Retires

After 43 years of continuous service, Paul Diserens, director of research and development of Worthington Corporation and its subsidiary companies, is retiring. He will continue with the corporation in a technical consulting capacity in engineering and research. Diserens joined Worthington, then known as International Steam Pump Company, in 1909 after graduating from Purdue University in 1904. In 1944 he was made director of research and development.

Ralph M. Watson has been named to succeed Diserens as director of research. He joined the Worthington organization in 1936 and in 1945 was made assistant to the vice president in charge of engineering. He is a member of Tau Beta Pi and the American Society of Mechanical Engineers, in which he serves as a member of the Power Test Code Committee on Centrifugal Pumps.

Westinghouse Names New Eastern Industrial Division Manager

Kenneth L. Horgan has been appointed Eastern District manager of the Industrial Division, Westinghouse Electric Corporation. Horgan succeeds J. S. Parry, Jr., who was recently transferred to East Pittsburgh, Pa., as assistant manager of the company's Apparatus Division. Prior to his appointment, Horgan was supervisor of the petroleum, chemical and communications section of the Industrial Division in the New York City office.

Davison Starts Construction On Triple Superphosphate Plant

Construction of a plant for the production of triple superphosphate has been started at Ridgewood, near Lakeland, Florida, by The Davison Chemical Corporation. Expected completion date has been set at October 1, 1953. The new project is part of a program under which the company will devote $25,400,000 to new and expanded production facilities.

The plant will produce sulfuric acid, needed in the manufacture of triple superphosphate. The Dorr Process for triple superphosphate production will be used, and the Dorr Company are architect-engineers for the plant, with the Consolidated Engineering Company as general contractors.

California Standard Gets Award For Tanker Operations

Standard Oil Company of California has received an achievement award from the Greater Los Angeles Chapter of the National Safety Council from Admiral Frank D. Higbee, vice president of the Chapter's Maritime section.

The award was presented for "the unsurpassed safe operation of tankers and the transfer of more than one hundred million barrels of refined petroleum without spillage or consequential mishaps in Southern California during the period of six years."

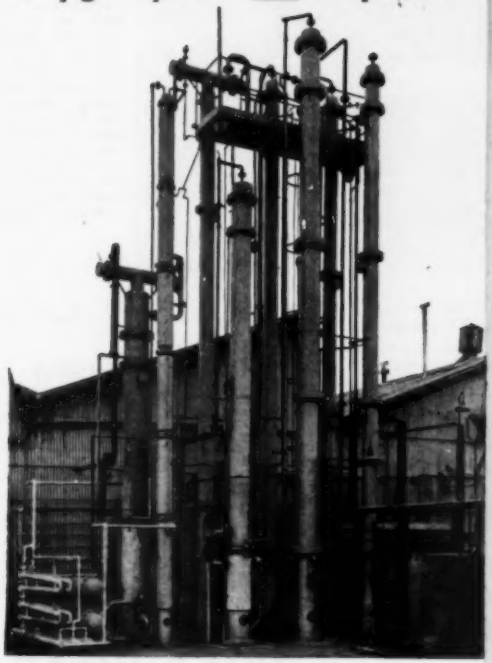
Robert White Elected Director Of American Locomotive Company

The election of Robert W. White as a director of the American Locomotive Company has been announced. Formerly a vice president and treasurer of Union Carbide and Carbon Corporation, White now is a member of Robert White Associates, business consultants, of New York. He is also a director of Corn Products Refining Company, Giant Portland Cement Company and the Carolina Giant Cement Company.

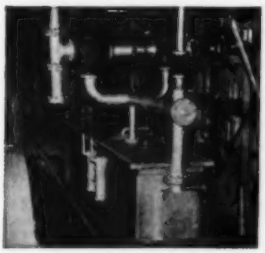
H. D. Leisenring Named Eastern Area Sales Head by A. O. Smith

The appointment of H. D. Leisenring as sales manager, eastern area, for the A. O. Smith Corporation has been announced. Formerly a sales manager, Pa-

Oxygen plant **not** required!



Wulff Process Recovery and Purification section. In operation over 19 months, the plant has sold acetylene commercially for the past 10 months.



This fully automatic cracking furnace is the heart of the Wulff Process. In the past 10 months of commercial operation, this unit has required no maintenance—capacities and yields have remained the same.

Available from Fluor

The Wulff Process for the production of acetylene from hydrocarbons is available through The Fluor Corporation. With over 30 years' experience in the design, engineering, and construction of plants and facilities for the petroleum and chemical industries, Fluor possesses the background, the skilled personnel, and the know-how essential for the practical application of the Wulff Process into your particular program.

THE WULFF PROCESS

Acetylene from natural gas, ethane, propane, butane, or any LPG mixture

available through Fluor!

The manufacture of acetylene from hydrocarbons by thermal pyrolysis is now commercially feasible and economically attractive! This has been proved. In January, 1951, the Wulff Process Company placed in experimental operation a commercial-sized acetylene plant. The plant has been operating continuously for the last 19 months. During the last 10 months of this period, acetylene has been sold commercially. This same process may be applied to plants making as little as one ton per day of acetylene to as much as one hundred tons or more per day.

The Wulff Process Company plant has experienced continuous operation on a wide variety of hydrocarbon feed stocks. Methane and propane have been used commercially. Test operations with ethane, butane and various hydrocarbon mixtures have demonstrated that a single plant with modification only in operating conditions can be used for a number of feed stocks. The process can be operated to produce substantial yields of commercial grade ethylene simultaneously.

Regardless of whether your activities lie in the production of petrochemical feed stocks, the manufacture of end petrochemical products, or both, it will pay you to investigate this commercially proven process for the recovery of low-cost acetylene from hydrocarbons. Your nearest Fluor representative will be pleased to provide detailed information on specific requirements. Contact him today!

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cific coast area for the Meter Division, he has over 20 years experience in engineering and sales of service station pumps and petroleum meters. Leisenring replaces Wilson Milligan who has resigned to go into business as a distributor of A. O. Smith Meter Division products.

American Cyanamid Transfers L. R. Forrest to Linden Plant

American Cyanamid Company has announced that L. R. Forrest has been transferred to the Warners plant, Linden, N. J., where he will serve as staff assistant to the Works Manager. Forrest, who formerly served with the Industrial Chemicals Division's New York Production department, will coordinate plant engineering and chemical engineering problems at Warners. He joined Cyanamid in 1929.

Shell Chemical Corporation Purchases Julius Hyman Company

Shell Chemical Corporation has completed arrangements to purchase the stock of Julius Hyman Company and has concluded an agreement with the Velsicol Corporation of Chicago for exclusive rights world-wide, to aldrin and dieldrin, agricultural insecticides.

Bridgeport Announces Two Changes

The Bridgeport Brass Company has announced two changes in its executive sales organization. George H. Baldwin, formerly sales manager Mill Products, has been promoted to assistant general sales manager. He is being replaced as sales manager Mill Products, by Richard L. Allen.

MOVED — The Woobank Machinery Company is now occupying new and larger quarters in Tulsa, Okla. For over 30 years the company has been the representative of the C. Lee Cook Manufacturing Company for the sale of piston rings and rod packings. The move will provide Woobank with larger office space and increased warehouse facilities.

Agricultural Chemicals Division Inaugurated by Shell Chemical

Shell Chemical Corporation, which recently purchased the Denver firm of Julius Hyman & Company, will centralize all of its agricultural chemical activity in Denver. According to J. Oostermeyer, Shell Chemical president, Denver will become the marketing headquarters for all of the firm's agricultural products, except fertilizers. Manufacturing and research activities are currently established at the Rocky Mountain arsenal plant nearby.

The new organization will be known as the Julius Hyman & Company Division of Shell Chemical Corporation and will market insecticides, aldrin and dieldrin, Shell's soil fumigants, and its line of spray oils which are marketed on the West Coast.

Robert C. Luckey Named Safety Engineer for Blaw-Knox Company

Robert C. Luckey has been appointed safety engineer for Chemical Plants Division, Blaw-Knox Construction Company. He will be responsible for the organization and administration of accident and fire prevention at Chemical Plants' field construction projects. In addition, he will be available to project managers and construction superintendents as a consultant on safety.

A graduate of Northwestern University, he has served in safety engineering

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27 minutes running time

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Strong, tough, long-lasting ENDURO stubbornly resists rust and corrosion. It resists the action of most acids and alkalies. Its hard, smooth surface discourages coking and fouling, and is easy to wash down quickly during "off stream" periods.

ENDURO maintains its great strength under prolonged exposure to intense heat or to sub-zero cold. Its strength-to-weight ratio is unusually high, making possible *thinner, bulk-saving sections.* ENDURO equipment *lasts.*

In your planning for new and expanded refinery facilities, think ENDURO. Several analyses are available now to help protect your "95%+"—and, Republic always is willing to work with you on any future development involving the use of stainless steel. Just write:

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W-K-M Valves for process service utilize the proved W-K-M expanding gate design, which provides a smooth bore right through the valve. Only in W-K-M Valves are the gates activated by the Leverlock Cam construction which guarantees years of positive operation at any temperature or pressure within the range of the valve.

W-K-M Process Valves are in service in fluid catalytic cracking units, propane de-asphalting units, vapor recovery units, hydroforming units and refinery fuel systems.

Write for Bulletin #698 for complete data concerning W-K-M Process Valves.

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W-K-M Valves

NEW OFFICES — General Welding Works has completed construction of a new office building, modern in every respect, air conditioned for both winter and summer, which contains more than 1350 square feet of floor space with special attention to drafting and engineering quarters.

capacities in powder plants, petroleum refining, Air Force Ground Safety, fire prevention and related phases of safety and security programs.

Swartwout Company Opens New District Sales, Service Office

The Swartwout Company has announced the opening of a new district sales and service office for the Power Plant and Autronic Control Divisions in Alhambra, Calif. The office, which will service southern California, Arizona and Clark county, Nevada, will be managed by Roger L. Gilliland.

Gilliland

Gilliland has been with the company for the past 10 years as a development engineer specializing in controller design and applications. Charles P. Crowley will continue to handle special power plant equipment accounts.

National Carbon Promotes Berdan, Warnell to Executive Positions

National Carbon Company, a division of Union Carbide and Carbon Corporation, has announced the appointment of F. W. Berdan as manager, automotive products sales, and J. F. Warnell, manager, battery products sales. Both executives will be located in the company's New York office.

Berdan joined the company in 1922 and in 1948 was made assistant general sales manager in New York. Warnell joined National Carbon as a salesman in 1933, and in 1948, he was promoted to manager of the Eastern District.

Beckman Instruments Plans Research-Manufacturing Unit

Officers of Beckman Instruments, Inc. have announced plans for erection of a large modern research and manufacturing center in the Fullerton-La Habra, Calif. area. The program is a long range plan and various divisions and manufacturing units of present operations will be moved to the new La Habra location only as suitable facilities are completed. The expansion is necessary, according to Dr. A. O. Beckman, president of Beckman Instruments and The Helipot Corporation, a subsidiary, to meet growing demand for company products. At present the company is situated in Pasadena and South Pasadena areas.

Davison Chemical Appoints Hope Manager Of Research Engineering

Ralph E. Hope has been appointed manager of research engineering of The Davison Chemical Corporation. For the past two years, Hope has been Davison's representative in Warrington, England, on the design and operation of a plant built by an affiliate of Lever Brothers & Unilever Ltd., for the production of petroleum cracking catalyst by the Davison microspheroidal process.

Hope

Prior to going to England, Hope was plant engineer at Davison's Cincinnati catalyst plant. He studied mechanical engineering at the University of Cincinnati and did graduate work in chemical engineering at the University of Michigan.

Askania Regulator Names West Coast Representatives

Askania Regulator Company has announced the appointment of Heat & Control, Inc., as its West Coast representatives. Heat & Controls headquarters are in San Francisco, and they will handle the complete Askania line of hydraulic automatic control equipment.

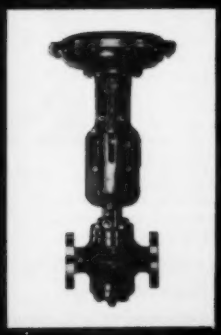
Aries & Associates Opens New Office In San Antonio

R. S. Aries & Associates, chemical engineers and economists, have announced the establishment of a regional office in San Antonio, Texas. The branch office operations will be directed by Alden H. Waitt, vice president of the Aries organization. He has been with Aries since 1950 as Washington representative.

Krumech Appointed Shippers' Car Line Corporation Vice President

John P. Krumech has been appointed vice president of Shippers' Car Line Corporation. Krumech, who has been traffic manager of the American Car and Foundry Company, of which Shippers' is the tank car owning and leasing subsidiary, will have his headquarters in New York. A native New Yorker and alumnus of the Pennsylvania and the Milwaukee railroads, Krumech came to ACF in 1920. He is a director of the

for safe, easy stem lubrication



The isolating valve in the stem lubricator of the Honeywell Series 700 Valve affords maximum safety against leakage when replenishing stem lubricant tight-fitting conical plug and machined seat assure leakless shut-off . . . pinned bonnet prevents accidental removal. The Honeywell Series 700 wide band proportional valve comes in a full range of styles and sizes . . . has *all* the features you look for in a fine valve. Write today for your copy of Bulletin 700-2.

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See Page 254 in Refinery Catalog

National Industrial Traffic League, a founder member of the American Society of Traffic and Transportation, The National Freight Traffic Association, the New York Railroad Club and the Transportation Club of the Petroleum Industry.

Black, Sivalls & Bryson Name Assistant Managers

Black, Sivalls & Bryson, Inc., has announced the appointment of four assistant regional managers for the Gulf Coast and West Texas regions. Paul Bartley, formerly Lafayette branch manager, has been named assistant regional manager for the Gulf Coast region. Ralph A. Stevens is manager of the Gulf Coast region. L. E. Jones, formerly Alice branch manager, is named assistant regional manager covering the Houston and Alice branches in the Gulf Coast region.

Bartley Reif Pool Jones

Appointed assistant regional managers for the West Texas Region are Ed Pool, formerly Odessa branch manager and Ed Reif, formerly Casper branch manager. H. C. Fessler, Midland, is manager of the West Texas region.

E. C. Medcalf Named by Cyanamid

E. C. Medcalf has been named head of the Coal Tar Chemicals Department of American Cyanamid Company, succeeding the late Q. T. Dickinson. He will be in charge of the purchase and sale of coal tar and light oil crudes. Prior to his present appointment, he was vice chairman of Chemicals Department Technical Committees.

American Cyanamid Announces Appointment of E. W. Koffman

American Cyanamid Company has announced the appointment of E. W. Koffman to the sales staff of the Industrial Chemicals Division's New York office. He formerly served as purchasing agent for the division and technical representative for the Petroleum Chemicals department. Koffman will assist in the sale of products of the Petroleum Chemicals department. Before joining Cyanamid in 1942, he was sales engineer with The Conditioning Company.

Barrett Division Opens Research Laboratory At Edgewater, N. J.

A new laboratory, specially designed to develop and test materials and processes used in the manufacture of plastics, rubber products, paints and varnishes, paper, laminates, insulating materials and a wide range of other products, has been opened in Edgewater, N. J., by Barrett Division, Allied Chemical & Dye Corporation.

The laboratory will be known as the Shadyside Applications Research Laboratory, and will be in charge of D. A. Rankin, superintendent. Containing extensive testing and actual production equipment, including mills, presses, calenders, extruders, molding machines and other special purpose machines, the laboratory will enable Barrett technicians to develop, test and evaluate, under simulated production conditions, materials used in the manufacture of plastics, paper and other products.

Fourth Generation to Management Position With Fairbanks-Morse

Fairbanks, Morse & Company, Chicago manufacturers, have recently announced that R. H. Morse III has been appointed general manager of the company's Beloit, Wis., works. This marks the fourth generation of the Morse family to come to the management staff of the company. He succeeds Orren S. Leslie who has been named manager of manufacturing and has been transferred to the company's headquarters. Morse, who will now direct all phases of operation at Beloit, was graduated from Princeton University with a degree in mechanical engineering. During World War II he served in the Navy for three and one-half years.

Simmons Elected Johnston Pump President And General Manager

Thomas W. Simmons, Jr., former vice president and general manager of Johnston Pump Company, has been elected president and general manager by a special meeting of the board of directors of the pump concern.

Simmons

According to Simmons, "There will be no change in our policies or plans."

Other directors of the company are Mrs. Mabel C. Simmons, chairman of the board; Earl Hupp, who is also secretary-treasurer; Charles L. Holbert, vice president in charge of finance; and Warren S. Pallette, general counsel.

Wagner Electric Names G. W. Brown Executive Engineer

The appointment of George W. Brown as executive engineer has been announced by the Wagner Electric Corporation. Brown has been with the company since 1926, having joined the company as a student engineer following his graduation from Ohio State University. During World War II, he served as a major assigned to the Office, Chief of Ordnance, Washington, D. C. Returning to Wagner after the war, Brown was appointed Industrial Relations di-

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COPPER ALLOY BULLETIN

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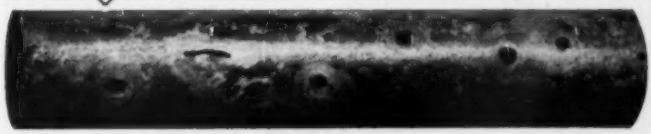

(Top, Fig. 1.) A non-inhibited Admiralty tube which failed from plug-type dezincification accelerated by the hot wall effect.

(Bottom, Fig. 2.) Photomicrograph of section of this tube. In the upper half of the corroded area, part of the copper plug has been converted into black copper sulfide, which has dropped out leaving a shallow pit. Unattacked Admiralty is evident on both sides of the corroded area. Mag. 25X.

Improving Efficiency and Extending Tube Life by Good Operating Practices

When a section of a refinery or chemical plant is shut down for major repairs and overhauling, careful examination and diagnosis of tube failures in condenser and heat exchangers are very important as the results may lead to remedying conditions which shortened tube life.

One of the major causes of copper-base alloy tube failures is operating them at temperatures higher than those for which the metal is designed to withstand comfortably. Even intermittent periods of excessive heat may do considerable damage. Consequently, temperature control of various operations is most essential.

A basic cause of overheating may be the clogging or blocking of the tubes which carry the cooling water or liquid. Cleaning and removal of debris at the inlet ends of the tubes should be done as often as necessary. This condition is aggravated during and after stormy periods and floods. The use of screens and strainers to keep foreign matter from entering the equipment can do much to keep the tubes from overheating. At one plant, shutdowns that occurred every six months have been changed to every 16 months and even longer through careful maintenance and control of operating conditions.

Tube Failure From Hot Wall Effect

Figure 1 illustrates a ¾" O.D., No. 16 BWG non-inhibited Admiralty tube which was removed from a thermal catalytic cracking unit in an overhead condenser. It failed from plug-type dezincification after four years service. The tubing had been installed in a horizontal position. Perforation had occurred in the ceiling of the tubing only.

A metallurgical examination of the tube wall showed that plug-type dezincification started from the inside (water side). When the plugs of copper extended completely through the tube wall, they were rapidly attacked by the sulfur compounds in the hydrocarbon liquid and vapors surrounding the outside of the tubes. The holes formed rapidly after the copper plugs had changed to copper sulfide.

The circulating water inside the tubing which was not particularly corrosive, averaged between 110-120°F at the exit end. The product temperature (on the outside of the tubes) was approximately 300°F.

The severe local corrosion which occurred is attributed to the hot wall effect. This occurs where bubbles or debris separate from the circulating water and cling to the metal surface at which points they act as localized heat insulators, the metal approaching the temperature of the hot liquid on the outside. Corrosion at these points proceeds at a higher rate due to the accelerating effect of increased temperature.

Dezincification Can Be Avoided

Dezincification would have been unlikely if arsenical Admiralty (inhibited against dezincification) had been used. This change in alloy should result in increased service life of the tubes.

Suggested measures for increased tube life are:

1. Increase velocity of coolant to dislodge bubbles of gas and debris, but avoid too high water velocities which lead to impingement corrosion.

2. Keep tubes clean. Remove debris, mud, silt or rust promptly.

Changing practice such as increased water velocities may lead to other types of attack such as impingement corrosion. If arsenical Admiralty does not stand up satisfactorily under these conditions, it would be well to consider the use of Arsenical Aluminum Brass which withstands impingement corrosion better than Admiralty and has equal resistance to sulphide corrosion. Where high temperatures are unavoidable and the sulfur content in the hydrocarbons is comparatively low, 70-30 Cupro Nickel should be tried out. This alloy has a higher creep strength at the higher temperatures than the brasses and is also much less affected by ammonia.

The Bridgeport corrosion laboratory will be glad to cooperate with corrosion engineers in refineries and chemical plants on their corrosion problems connected with copper-base alloy tubes.

(8550)

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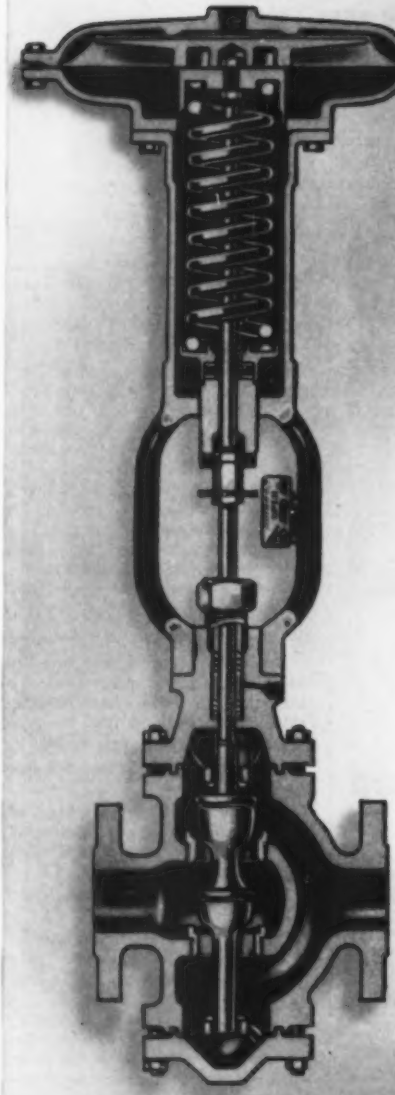

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rector. Recently, he was appointed executive engineer and given the responsibility of general executive direction of the electrical engineering, automotive engineering and metallurgical and chemical departments.

Engineering Instructors Attend Foxboro Instrumentation Seminar

Engineering instructors from 10 of the country's colleges and universities recently attended a two-week seminar in instrumentation at The Foxboro Company. Purpose of the program was to supply information and assistance to faculty members who teach instrumentation and other technical subjects which require an understanding of instrument application. The third annual course of its type to be offered by The Foxboro Company Training and Educational Division, the program furnished an intensive review of current practices and developments in the field of instrument engineering.

Buhrer, Kleinsmith Made Vice Presidents of National Carbon

P. M. Buhrer and C. O. Kleinsmith have been appointed executive vice presi-

Buhrer

Kleinsmith

dents of National Carbon Company, a division of Union Carbide and Carbon Corporation. Both men have been with National Carbon for many years, Buhrer having been associated with research and development activities and Kleinsmith with sales. Buhrer is a 1923 Johns Hopkins University graduate and a native of Tiffin, Ohio, while Kleinsmith was born in Cleveland and attended Case Institute of Technology.

Administrative Shifts Announced

A new alignment of administrative responsibility in the sales department of General Controls Company has been announced. Fred Weldon has been appointed sales manager of the company and manager of the new Skokie, Ill., factory. William L. Kell, assistant sales manager, has been additionally assigned as manager of the heating controls division. R. D. Grayson has been named manager of the appliance controls division. Rudy Roedder has been appointed Western Refrigeration Controls division manager, under the supervision of Douglas Sterner.

Jefferson Houston Office Set-Up

Ben C. Hayton who has been appointed a representative on the Sales department staff of Jefferson Chemical Company, Inc., shortly will establish a sales office in Houston. Hayton, who received a B.S. degree in chemical engineering from Rice Institute in 1945, joined Jefferson in 1946.

FIRST SHIPMENT—The first tank-car of Ethyl antiknock compound to be manufactured at the new Ethyl plant on the Houston Ship Channel arrived at the neighboring Sinclair refinery in Houston recently where it was to be added to Sinclair's gasoline. On hand to note the arrival were, left to right R. B. Thacker, Sinclair assistant superintendent; Wallace F. Armstrong, Ethyl plant manager; J. D. Seifer, operating superintendent, Sinclair; Parker Kendall, assistant general manager of refineries, Sinclair; R. W. Green, foreman, Sinclair's Cargo and Terminal department; Howard J. Gerber of Ethyl, sales representative; C. C. Stovall, assistant foreman, Sinclair; and Clinton W. Bond of Ethyl, general manager of manufacturing.

Worthington Names Kansas City, Milwaukee Branch Managers

Worthington Corporation has appointed Paul J. Foley manager of its Kansas City office and William M. Fine manager of its Milwaukee branch office. Foley joined Worthington in 1937 and became a sales engineer in the company's Chicago office and later was made manager of its Milwaukee branch office. A graduate of Northeastern University, he is a member of the American Society of Mechanical Engineers.

Fine was graduated from Lehigh University in 1939 with a B.S. degree in industrial engineering where he was elected to Pi Tau Sigma. He then joined Worthington and became an estimating engineer in the company's Chicago office. In 1943 he joined the sales force.

R. H. Mattson Joins Jefferson's Market Development Division

Dr. Raymond H. Mattson has recently joined Jefferson Chemical Company, Inc.'s Market Development staff, which operates as part of the sales department. Mattson, who received his Ph.D. in organic chemistry from the University of Illinois in 1951, was formerly employed as a research chemist with American Cyanamid Company and with Rohm and Haas Company.

R. James Robinson has also joined Jefferson as representative on its sales department staff. Robinson was graduated from Case Institute of Technology in June of this year with a B.S. in chemical engineering.

Van Norden Named American Meter Sales Representative

John D. Van Norden has been recently added to the staff of the Atlanta sales territory of American Meter Company as sales representative. He is a graduate of Yale University and was associated with United Engineering and Constructors, Inc., prior to becoming a member of the American Meter organization. A veteran of World War II, Van Norden will assume his duties after undergoing a period of factory training designed to qualify him in the company's complete line of displacement meter, accessory instruments apparatus, regulators, orifice meters and allied instruments.

Van Norden

Beckman Instruments Opens Large New Synchro, Components Factory

Beckman Instruments, Inc., has announced the opening of a large new plant devoted exclusively to the manufacture of synchros and associated components, bringing the number of Beckman plants to 15. The new plant, specially-designed to house synchro operations, is entirely air-conditioned and is equipped with special electrostatic dust filters to permit high-precision manufacturing techniques.

M-H Opens New Houston Office

Minneapolis-Honeywell Regulator Company has announced the opening of a new Houston office, located at 5440 Gulf Freeway. Company officials say the move was made to increase service and convenience for customers.

Griscom-Russell Company Marks 85th Birthday With Celebration

The Griscom-Russell Company held a "Family Day" recently to mark the 85th birthday of the company, and at the same time signalize the consolidation of its entire executive, administrative, engineering and general sales departments at Massillon, Ohio. The company originally moved its manufacturing operation to Massillon in 1912. Last fall the company moved its general offices from New York City to Massillon to

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PYREX Brand Gauge Glasses withstand severe physical and thermal shock. Uniform dimensions give tight accurate fittings. Replacements are minimized, freeing your men for more important maintenance work.

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provide efficient coordination of the work of all departments.

During the celebration, more than 2100 employes and members of their families made guided tours of the plant.

W. A. McAuley, R. P. Northup Named To Crouse-Hinds Condulet Sales

Russell P. Northup, Crouse-Hinds Company commercial vice president, assistant sales manager, has been assigned full responsibility for Condulet sales. Northup has served 17 years with Crouse-Hinds as field representative and assistant sales manager.

Northup

McAuley

Simultaneously, William A. McAuley has been appointed manager of the Condulet department in Syracuse, N.Y., in which capacity he will assist Northup.

Celanese Chemical Division Names Elbin District Manager

The Chemical Division of Celanese Corporation of America has promoted E. F. Elbin to district manager for the Southwest territory. He will represent the Chemical Division's organic chemicals and organic phosphates departments in New Mexico, Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama and part of Florida.

Elbin formerly lived in Cumberland, Md., and has been with Celanese Corporation since 1935.

Richard Bode Joins Ladish Valve In Executive Capacity

Ladish Company has announced the appointment of Richard M. Bode to an executive sales position in its Valve and Fittings Division. Formerly with Tri-Clover Machine Company as vice president and sales manager, Bode will be responsible for the marketing of a new line of valves.

Bode

Bode's appointment was announced simultaneously with the introduction of the new line of forged steel valves.

Three New Sales Executives Appointed by Bridgeport Brass

The Bridgeport Brass Company has appointed Chester M. Adams as general sales manager to direct the sales of all of their products. George H. Baldwin, formerly sales manager, Mill Products, has been made assistant general sales manager and Richard L. Allen has been appointed as their sales manager of Mill Products for both the Bridgeport, Conn., and Indianapolis, Ind., plants of the company.

Ashcroft Centennial Held By Manning, Maxwell & Moore, Inc.

Manning, Maxwell & Moore, Inc., has held a two-day centennial celebration at its Stratford, Conn., plant in honor of the 100th anniversary of its Ashcroft Pressure Gauge line of products.

It was in 1852 that the first Ashcroft Gauge was manufactured. The gauge was named for its inventor, Edward H. Ashcroft who, during his lifetime, held over 60 patents covering many different types of industrial products.

The celebration was attended by stockholders, company executives, industrial distributors and vendors. A tour of the new Stratford plant was included as part of the celebration.

Kingerley Named Wolverine Assistant Sales Manager

E. J. Campbell, midwestern district sales manager for Wolverine Tube Division of Calumet and Hecla Consolidated Copper Company, has announced that he has appointed A. S. Kingerley as his assistant. Kingerley has held various sales positions with the company since 1927. In his new position, his jurisdiction will cover sales in Michigan, northern Ohio and a portion of Indiana.

Kingerley

Timken Roller Directors Elect J. A. Riley Secretary-Treasurer

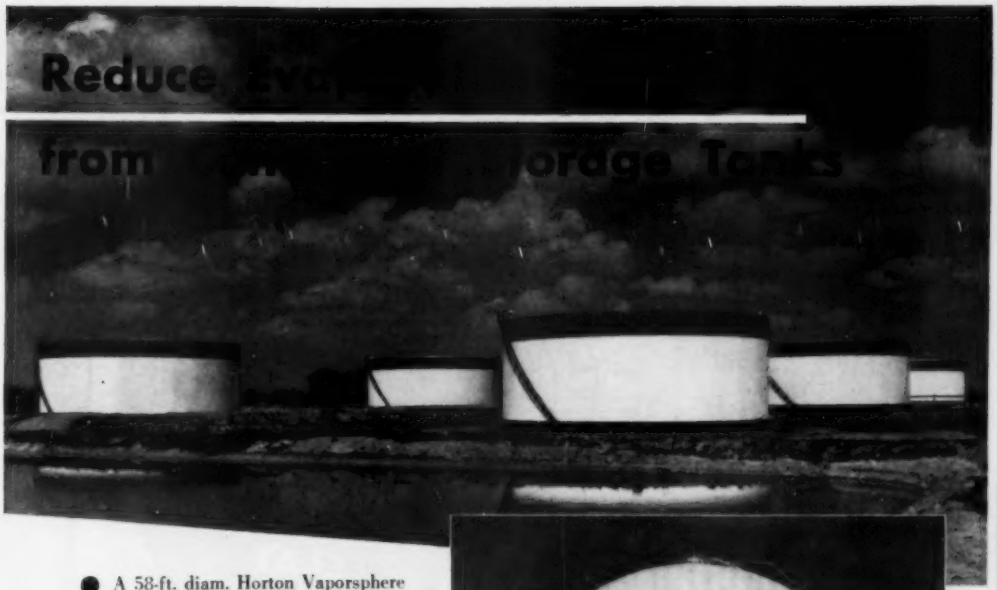
The Board of Directors of The Timken Roller Bearing Company has elected John A. Riley to the post of Secretary and Treasurer. Riley succeeds to the position vacated by the late R. C. Brower. Riley joined Timken in 1925 as comptroller after 18 years in the banking and public accounting business. He is a master Mason and member of the King Solomon Lodge of Elyria, Ohio.

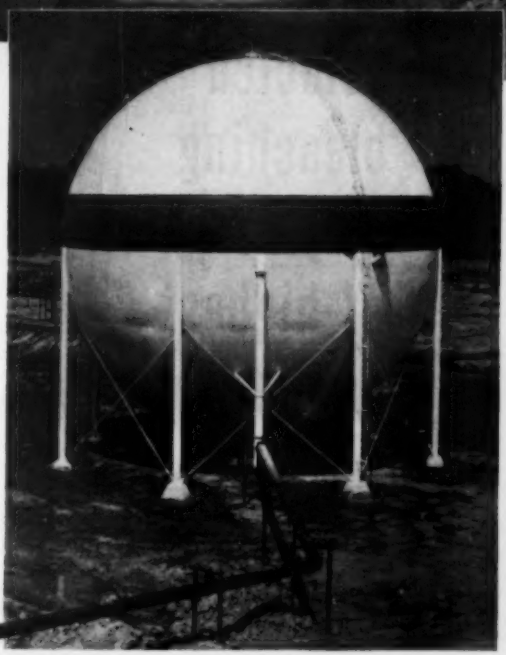
Ethyl Corporation Announces Several Recent Appointments

The appointment of Matthew A. Taylor, assistant manager of the Eastern sales region, to the post of manager of sales operations, heads a list of promotions announced by the Ethyl Corporation. Donald S. Flynn and George P. Rosser, account representatives, have been named assistant managers of the Eastern region. Other promotions announced are those of William K. McCulloch, sales promotion manager, to assistant manager of the advertising and sales promotion department, and Donald J. Chapman, account representative in the Western region, to sales promotion manager.

Under the re-organization of the advertising and sales promotion department, of which Russell B. Weston is manager, Frank A. Howard, Jr., will be in charge of advertising, and Edwin J. Enoch, Jr., will continue to be in charge of advertising and sales promotion. Another change announced is the creation of district managerships, in place of

Reduce Evap
from Cone Roof Storage Tanks





● A 58-ft. diam. Horton Vaporsphere with a capacity of 100,000 cu. ft. is reducing evaporation losses from cone roof tanks for the Rock Island Refining Corporation at Zionsville, Indiana. Connected to the vapor spaces of the cone roof tanks by large-diameter piping to form an efficient vapor gathering system, the Vaporsphere provides temporary storage space for displaced vapor due to thermal expansion or filling operations.

The Vaporsphere (shown at the right) consists of a spherical steel shell and a flexible hemispherical membrane, the outer edge of which is connected to the inside of the shell at the equator. Connected to the vapor spaces of one or more fixed roof tanks (such as the five 55,000-bbl. Horton cone roof tanks shown above), displaced vapor enters the Vaporsphere under the membrane and is stored temporarily. When conditions causing the outflow are reversed, the vapor returns to the tanks.

Further information concerning the Horton Vaporsphere or other Horton tanks and steel plate work for the petroleum industry may be had by writing our nearest office.

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Birmingham 1	1548 North Fiftieth Street	Havana	402 Abreu Building	San Francisco 4	1551—200 Bush Street
Boston 10	1030—201 Devonshire Street	Houston 2	2126 C & I Life Building	Seattle 1	1331 Henry Building
Chicago 4	2463 McCormick Building	Los Angeles 17	1534 General Petroleum Building	Tulsa 3	1626 Hunt Building
Cleveland 15	2234 Guildhall Building	New York 6	3302—165 Broadway Building	Washington 6, D. C.	1128 Cafritz Building

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Sociedade Chibridge de Construcoes Ltda., Av. Franklin Roosevelt, 194-S/704-C, Rio de Janeiro, Brazil
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Our expanding workload presents many opportunities for men with experience in engineering and design of oil-refineries and chemical-process plants.

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resident managerships, throughout the four sales regions. Appointments to district managers are: Roy L. Goltz, Robert W. Richardson, Eastern region; Harry A. Mack, George W. Rose, and Robert R. Mead, Central region; Leonard L. Huxtable, Russell Schell, J. O. Balzer, Alan C. Tully, Southern region; Monroe F. Weil, William H. Sievert, John S. Cole, Western region. In addition, Gelston Howell, account representative in Western Pennsylvania, has been transferred to the New York office.

Warren Representative Named

Warren Steam Pump Company, Inc., has announced the appointment of Process Industries Engineers, Inc., Pittsburgh, Pa., as their representatives on industrial sales for the Cleveland area. Arch. T. Miller, formerly sales engineer for Patterson Foundry & Machine Company, will be district manager of the Cleveland office.

U. S. Steel Appoints Frame

The appointment of William M. Frame as executive assistant, operating department, has been announced. Frame has recently been vice president and works manager, Kerotest Manufacturing Company.

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Engineering degree and several years oil refinery metals inspection experience required. Will be required to arrange and conduct inspections of oil refinery equipment, request equipment renewals due to corrosion, failure, or defectiveness in conformance with accepted safety codes. Will conduct tests of equipment, study cause and prevention of corrosion and failure of metals.

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Must have engineering degree and several years oil refinery or chemical plant experience. Will work in planning, scheduling, and coordination of oil refinery maintenance and construction.

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The industry that builds a fractionating tower more than 126 feet in length . . . 12 feet inside diameter . . . and weighing more than 180 tons . . . just has to know how to meet the problems of delivering it. Every problem that might be met along hundreds of miles of railway has to be known and planned for.

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The Sun-built refineries and chemical equipment serving in every part of America and in many foreign lands shows how well Sun men and management have mastered the problems of delivering the equipment they have produced in helping build a greater America.

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SCRAPED SURFACE *Exchangers*

*DOUBLE PIPE UNIT. Drive end close-up of 12 section unit under test in our shop.

*SHELL and PIPE UNITS. Two of five units installed in a leading petroleum refinery.

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IF you are all "gummed up" with a tough heat transfer problem, Vogt Scraped Surface Exchangers will provide the answer. They have patented scraper elements which prevent fouling of the heat transfer surfaces and insure the highest rate of heat exchange between the product and the cooling or heating medium. The scrapers also continuously agitate the fluid and assist removal of solids from the unit.

DOUBLE PIPE EQUIPMENT is available in two types; EXCHANGERS, for cooling with water, brine, and cold filtrate, and for heating with steam or hot liquids; and CHILLERS, for use with volatile refrigerants such as ammonia, propane, and Freon. Both types have 8" jacket pipes and 6" inner pipes with scrapers.

SHELL AND PIPE TYPE UNITS are designed for use with volatile refrigerants and for heating fluids with steam or similar heating mediums. They consist of large welded shells each containing seven 6" scraped pipe sections.

Vogt Scraped Surface Exchangers serve profitably as oil chillers, crystallizers, and heaters in many processes in the petroleum and chemical industries. Their application to your heat transfer problems will receive the prompt attention of our Engineering staff.

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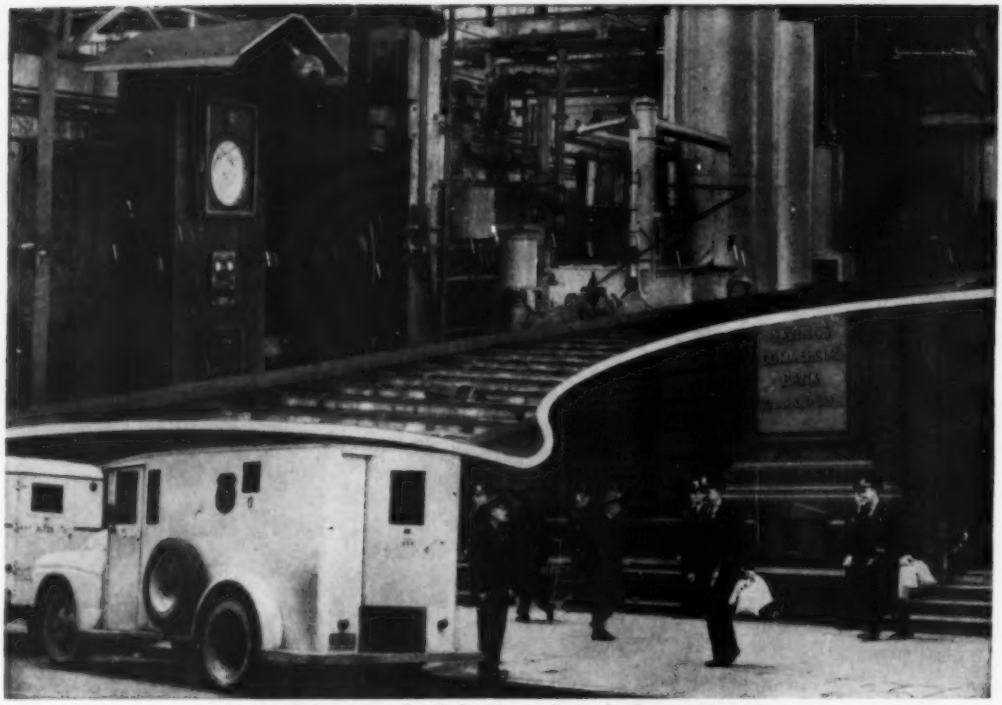

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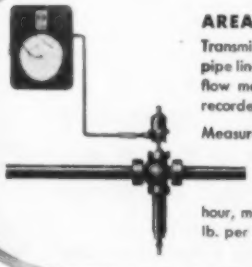
Your local Bailey Engineer is as near as your telephone. He has the experience and the equipment necessary to set up an effective guard for your process materials.

P-26



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Transmitter goes into 1, 2 or 4 inch pipe line like a valve and transmits flow measurements electrically to recorder in remote location.

Measures oil and other clear liquids under static pressures up to 600 psi. Minimum range 0 to 1200 lb. per hour, maximum range 0 to 9600 lb. per hour.

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TEMPERATURE · FLOW
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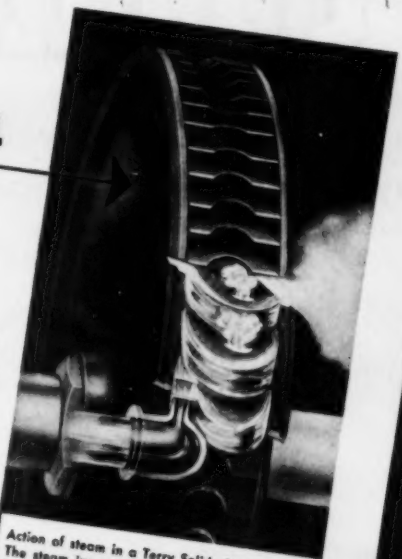
has no parts to loosen or work out

The rotor of the Terry Solid-wheel Turbine is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to become loose or work out.

The power-producing action of the steam takes place on the curved surfaces at the back of the buckets. Hence, wear of the blades is of little consequence, as it does not materially affect horsepower or efficiency. There is practically no end thrust since the steam enters and leaves the wheel in a direction at right angles to shaft.



Action of steam in a Terry Solid-wheel Turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

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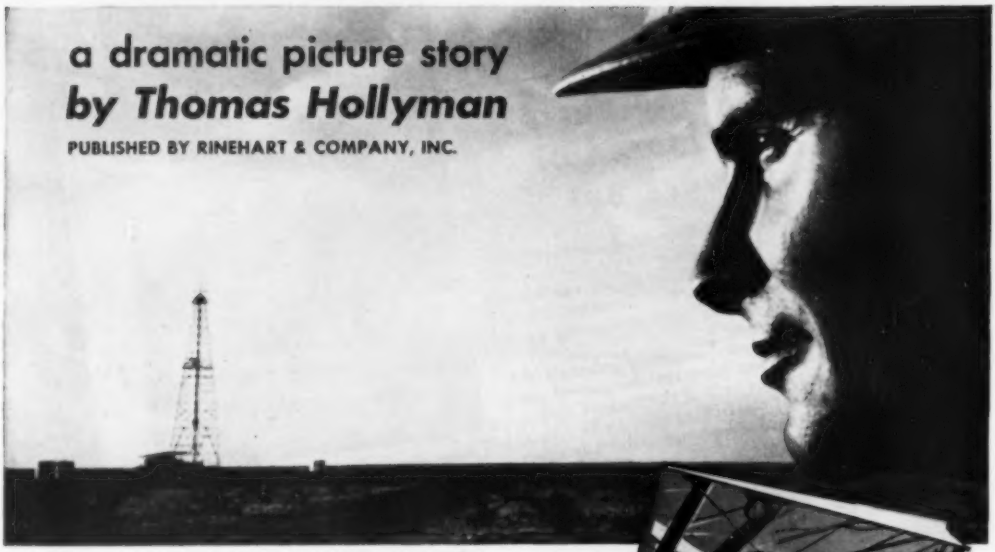

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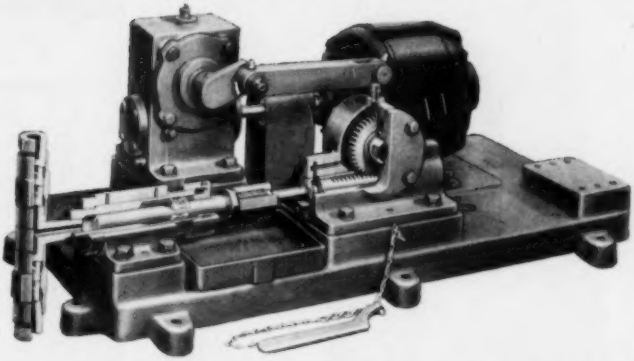

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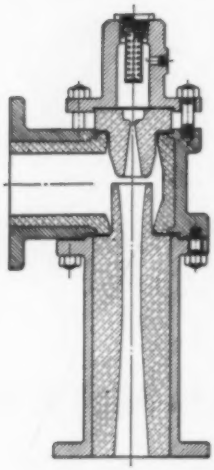

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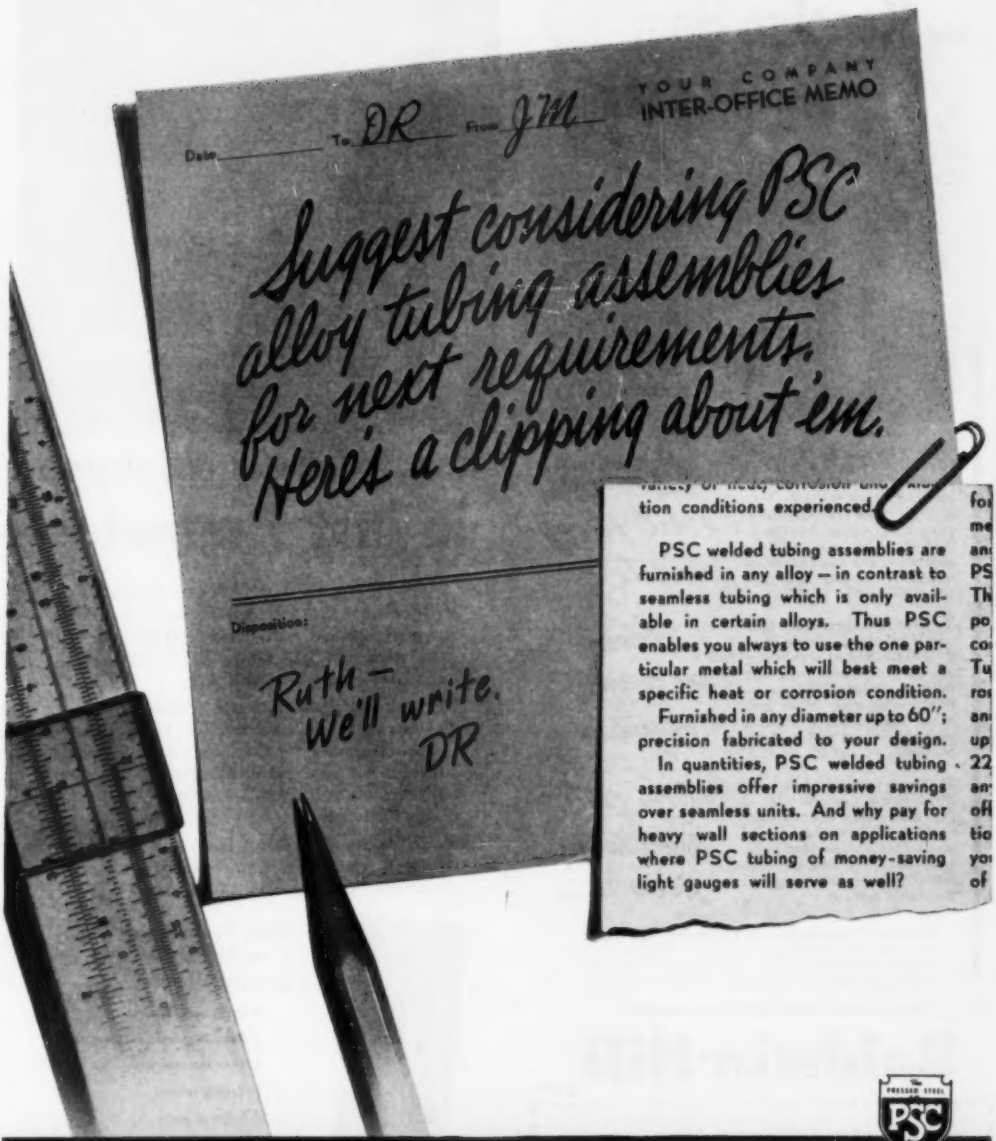
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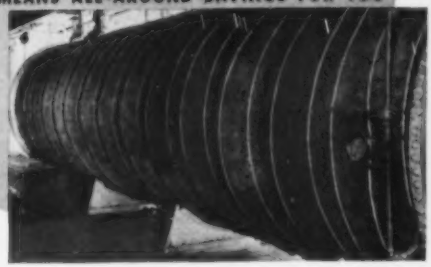

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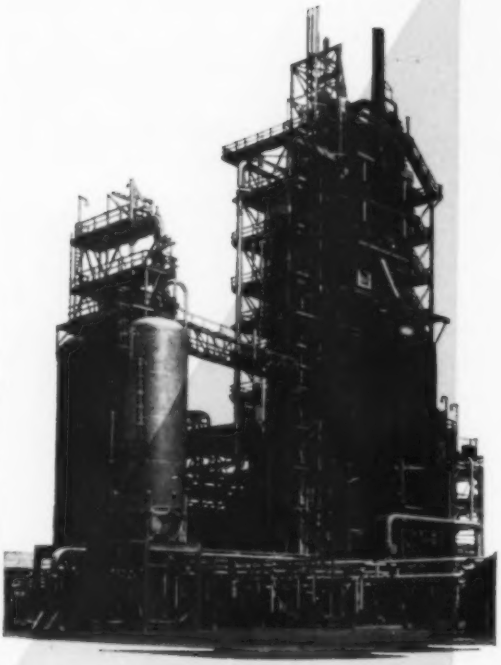

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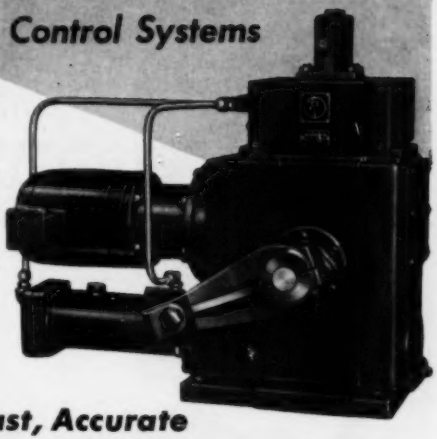

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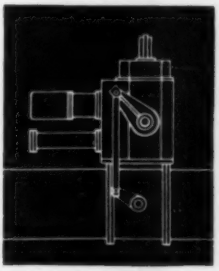

This illustrates a typical installation on a butterfly valve—also applicable to rising stem plug valves and slide valves.

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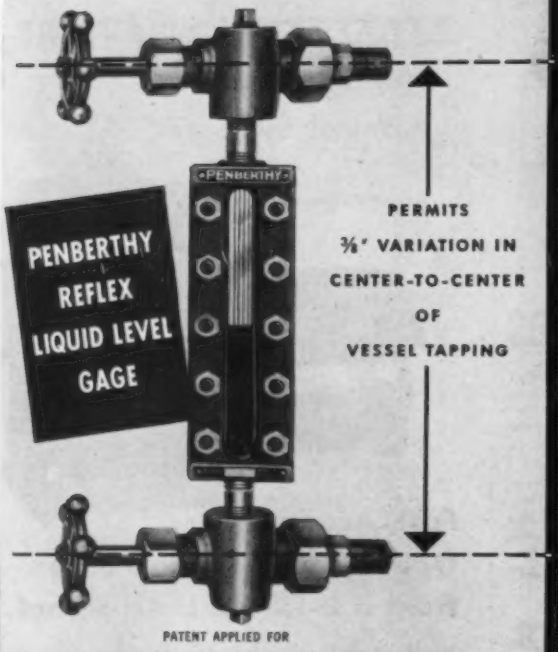

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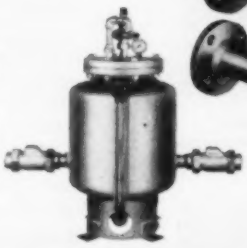

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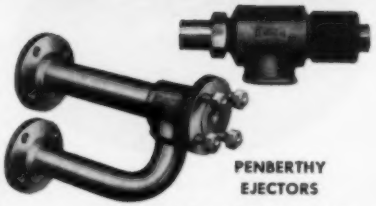

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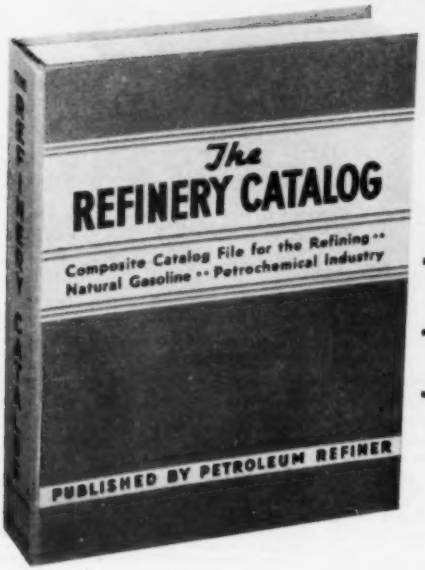
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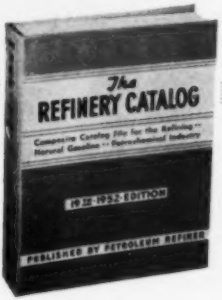

A

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Askania Regulator Co. 215

B

*The Babcock & Wilcox Co. 28-29, 53, 148-149
*Badger Manufacturing Co. 164
*Bailey Meter Co. 206
*Baldwin-Hill Co. 212
Baroid Sales Division
National Lead Co. 202
The J. B. Beaird Co. 40
*Beaver Pipe Tools, Inc. 189
Big Three Welding Equipment Co. 25, 189
*Black, Sivalls & Bryson, Inc. 30
*Blaw-Knox Co. 160, 183
*Bridgeport Brass Co. 197
The Bristol Co. 17
Brown & Root, Inc. 63
*Buell Engineering Co. 147
Byron Jackson Co. 127

C

Calumet and Hecla Consolidated
Copper Co. 186
Carrier Corp. ..... Opp. 189
Cast Iron Pipe Research Assoc. 210
Catawissa Valve & Fittings Co. 177
The Chapman Valve Manufacturing Co. 131
*Chemical Construction Corp. 129
Chicago Bridge & Iron Co. 201
Chicago-Wilcox Mfg. Co. 196
*Childers Manufacturing Co. 26
*Clark Bros. Co. 171
The Clark Manufacturing Co. 130
Condenser Service & Engr. Co. 215
*Corning Glass Works 200
*Crane Co. 123
*Croll-Reynolds Co. 210

D

The Davison Chemical Corp. ..... Opp. 121
S. D. Day Co. 215
*Dean Brothers Pumps Inc. 169
Dempster Brothers, Inc. 33
*Dresser Industries, Inc. 45
*Dresser Operations, Inc. 171
E. I. du Pont de Nemours &
Co. ..... 46, 151, Insert 156-157
*The Duraloy Co. 142

E

*The Eagle-Picher Co. 14-15
Electric Steel Foundry 5
*Elliott Co. 119
Enjay Company 172
Ethyl Corp. ..... Insert 32-33

F

Fischer & Porter Co. 35
*Fisher Governor Co. 198
*The Flinor Corp. 191
*Food Machinery and Chemical Corp. 31
*Foster Wheeler Corp. 139
The Foxboro Co. 136-137

G

General Chemical Division
Allied Chemical & Dye Corp. 158
*General Electric Co. 10-11
A. P. Green Fire Brick Co. 214
*Grinnell Company 44
*The Griscom-Russell Co. 178
*The Gulf Publishing Co. 213, 217
Gunite Concrete & Construction Co. 190

H

Hills-McCanna Co. 200

I

Industrial Pyrometer Co. 177
*Ingersoll-Rand Co. 144
Instruments, Inc. 196
*International Engineering, Inc. 145
The International Nickel Co. 34, 220

J

*The C. O. Jelliff Mfg. Corp. 192
*Johns-Manville Corp. 24

K

*Kaylo Division
Owens-Illinois Glass Co. 168
*Keasbey & Mattison Co. 39
*The M. W. Kellogg Co. 20-21
The C. M. Kemp Mfg. Co. 126
Kerrigan Iron Works, Inc. 181
*Koch Engineering Co. 133

L

*Ladish Co. ..... Opp. 188
Layne & Bowler, Inc. 32
Lee Construction Co. 173
Leeds & Northrup Co. 8
Warner Lewis Co. 173
*The Lummus Co. 9

M

Manning, Maxwell & Moore, Inc. 38
The Master Electric Co. 182
*A. Y. McDonald Mfg. Co. ..... IV Cover
*Arthur G. McKee & Co. 125
*Metal Goods Corp. 64
The Midvale Co. 154
Minneapolis-Honeywell Regulator Co. 195
*Mixing Equipment Co. 48
*Murray Iron Works Co. 187

N

*National Carbon Co. 162
National Lead Co. 202
*W. H. Nicholson & Co. 183

O

*Oakite Products, Inc. 212
*Oil Well Supply Division
United States Steel Co. 59
*Orbit Valve Co. 56
*Owens-Illinois Glass Co. 168

P

Pacific Tube Co. 143
Page Steel & Wire Division
American Chain & Cable Co. 140
*Peerless Pump Division
Food Machinery & Chemical Corp. 31
*Penberthy Injector Co. 216
Perco Division
Phillips Petroleum Co. 176
*Petro-Chem Development Co. 146
Petrolite Corp. 41
Phillips Petroleum Co. 176
Pittsburgh Lectrodryer Corp. 43
The Wm. Powell Co. 184
*The Pressed Steel Co. 211

R

Reading-Pratt & Cady Division
American Chain & Cable Co. 132
*The Refinery Engineering Co. 167
Refinery Supply Co. 185
*Republic Steel Corp. 18, 193
*Revere Copper & Brass Inc. 219
The Ric-Wil Co. 190
*The Ridge Tool Co. 128
*Rochester Manufacturing Co. 175
*Rockwell Manufacturing Co. ..... Insert 64-65
*Rockwood Sprinkler Co. 3
*Roots-Connersville Blower Corp. 45

S

Shand & Jurs Co. 22
Shell Oil Co. 208
Sier-Bath Gear & Pump Co. 136
Sims Pump Valve Co. 150
Six Wheels, Inc. 134
The Edward Soph Co. 200
*Stone & Webster Engineering Corp. ..... Opp. 120
*Struthers Wells Co. 16
*Sun Shipbuilding & Dry Dock Co. 204
Superior Manufacturing Co. 192

T

Tennessee Eastman Co. 141
*The Terry Steam Turbine Co. 207
Texas Pipe Bending Co. 23
The Timken Roller Bearing Co. 4
*The Titusville Iron Works Co. 16
*Tubular Products Division
The Babcock & Wilcox Co. 148-149

U

*Union Asbestos & Rubber Co. 54
*Union Carbide and Carbon Corp. 162
United States Gasket Co. 166
United States Steel Co. 59

V

*Henry Vogt Machine Co. 205

W

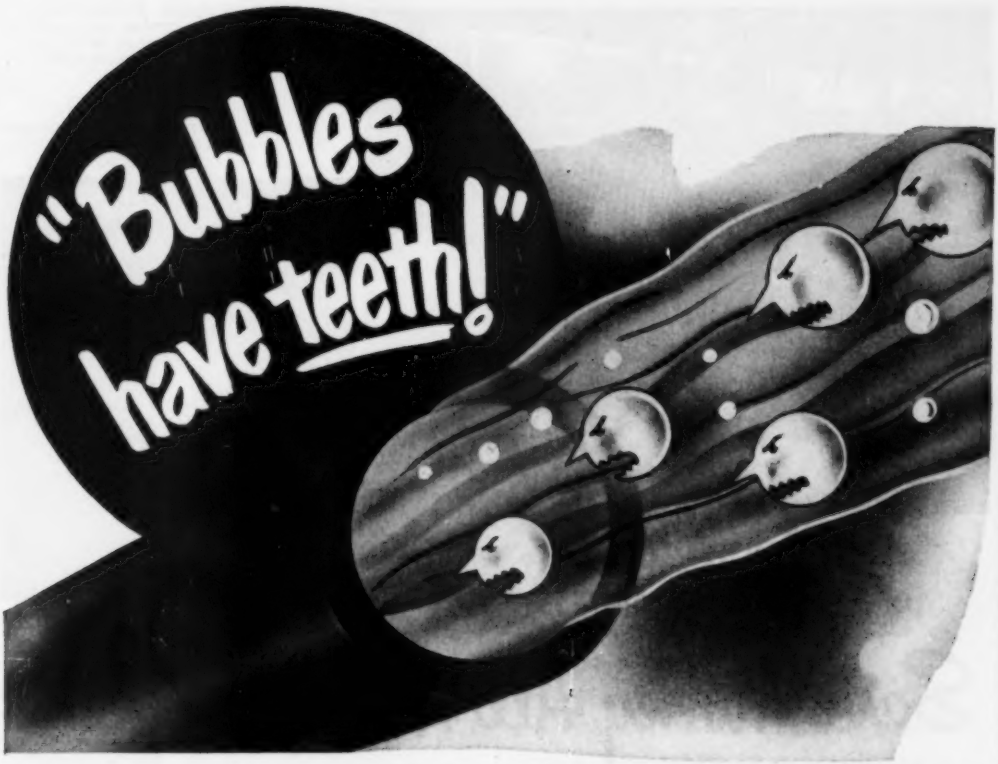
*W-K-M Company, Inc. 194
Walworth Co. 174
Warren Petroleum Corp. ..... I Cover
*Watson-Stillman Co. 180
Whiton Machine Co. 175
Wolverine Tube Division, Calumet and
Hecla Consolidated Copper Co. 186
*Worthington Corp. 6-7
Wyatt Metal & Boiler Works ..... III Cover

Y

*Yarnall-Waring Co. ..... II Cover

Z

*Zallea Brothers 27



QUITE a number of years ago Revere coined the phrase "Bubbles have teeth." This refers to the fact that what is called air entrainment is highly damaging to condenser tubes. Bubbles carried along with the cooling water set up a strong disturbance in it, disrupting the film that should protect the metal, and actually seeming to eat away the tube. The oxygen contained in the air bubbles also is destructive. Fortunately, the effects of air entrainment on condenser tubes are sufficiently distinctive to permit Revere Research to detect the trouble by examination of short lengths cut from tubes that have failed before their time.

Thus it happens that every once in a while the Research Department in Rome, New York, working through the Technical Advisory Service, is able to say that there is air leaking into a condenser it has never seen, in a far-off state. The problem then is to seal the water system against the entrance of air. This is not always an easy task, and it is one that the Revere Technical Advisory Service is glad to tackle together with the customer if asked to do so. After all, we want our condenser tubes to last as long as possible; that's what makes customers happy, and builds and preserves our reputation as producers of fine tubes.

In one such instance of bubble trouble, the operator, a public utility, could find no visible sign of a leak. Checking and tightening every bolt and seal produced no results. Finally it was decided to put plate glass windows in some of the inspection plates, in order to see what was going on inside. This located the defect, a stream of bubbles being easily seen pouring out of a gasket. The water was flowing past that gasket with sufficient velocity to suck air in.

In another instance, a few samples of failed tubes from an oil refinery (located almost 3,000 miles away from the utility) were sent to Revere's Research Department. The refiner was told that his trouble was due to bubbles. Again, a check of the condenser showed nothing. The water inlet and outlet lines and all gaskets and bolts seemed to be perfectly tight. Here was another puzzler. But once again it seemed plausible to assume that air was being drawn in where water velocity was high enough to create a suction. The search finally went all the way back to the water pumping station, where two cracked castings were located. Air sucked in through two tiny cracks was enough to do a lot of damage; bubbles do indeed have teeth.

Revere will gladly consult with you concerning condenser tubes, their selection, specification, and conditions of use. For condenser tubes and tube sheets in all the usual alloys, see Revere.

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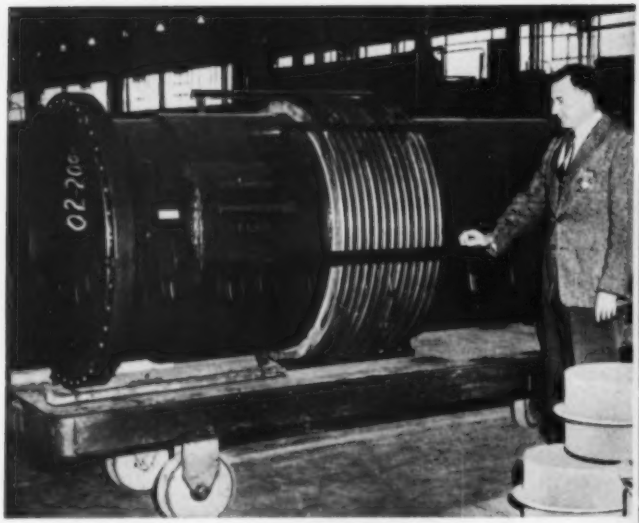

CATALYTIC CRACKER EXPANSION JOINT ASSEMBLY . . . one of the larger sizes of Sola-Flex equipment of this type fabricated from stainless chromium-nickel steel.

WELDING STAINLESS STEEL FABRICATED expansion joint assembly at Solar Aircraft Company's San Diego plant.

EXPANSION JOINTS OF STABILIZED STAINLESS

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In oil refineries, chemical plants, steam and gas turbine installations . . .

Wherever pipe carries material at elevated temperatures . . . subjecting components to thermal expansion and contraction . . . that's the field for stabilized stainless steel bellows and expansion joints.

A new line of such equipment has been developed by Solar Aircraft Company of San Diego, California, and is now available under the trade name "Sola-Flex."

Made from chromium-nickel stainless steels of the stabilized types (A.I.S.I. Types 321 and 347) "Sola-Flex" bellows and expansion joints have established completely satisfactory performance records in a variety of rugged applications.

In addition to high strength and corrosion resistance, these types of stainless steel, in gauges from .005" to .125", possess good forming and welding characteristics, and withstand fatigue, impact, wear and abrasion.

Industrial applications demand such properties. For example, expansion components to accommodate 6" to 36" pipe in a large catalytic cracking plant called for the stamping and forming of more than 600 diaphragms. And since the pipe carries a highly abrasive catalyst dust at 1100°F., it requires the hardness, creep-strength and stamina which stabilized chromium-nickel stainless provides.

The bulk of nickel produced at present is being diverted to defense. However, through application to appropriate authorities, chromium-nickel stainless steel is obtainable for many end uses in defense and defense supporting industries. Counsel and data on alloys containing nickel, for your present or future projects, are yours for the asking. We invite your inquiries.

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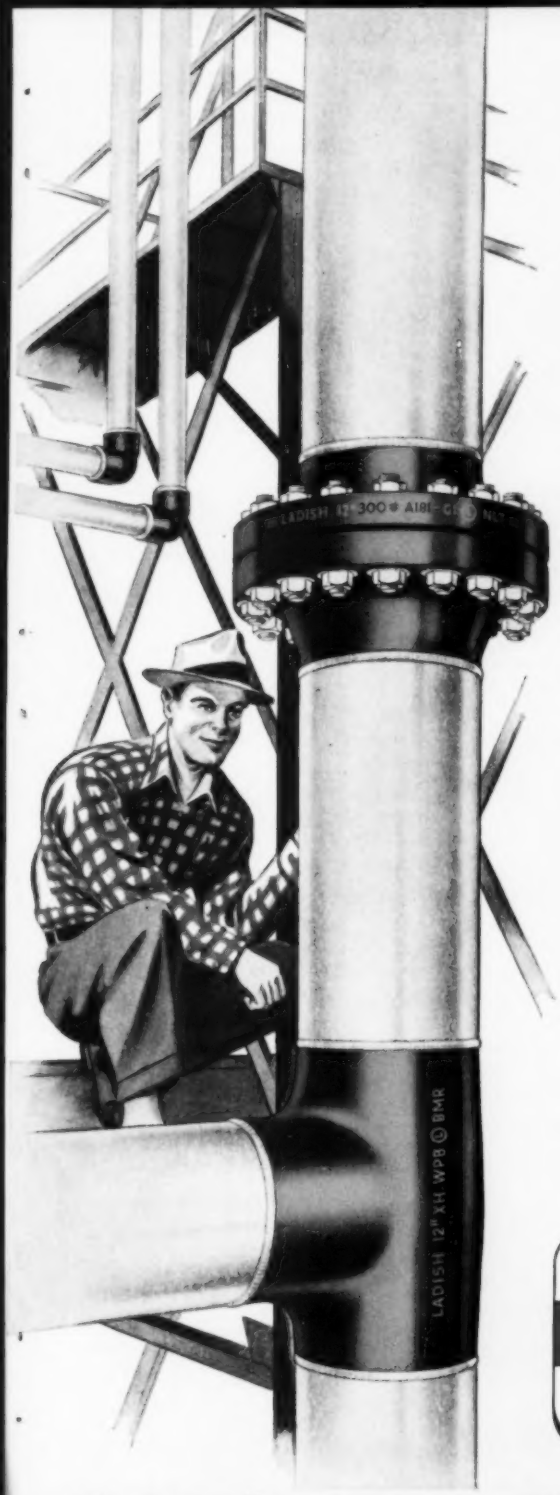

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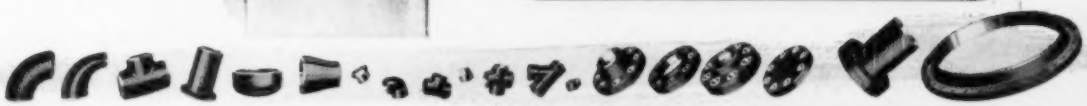

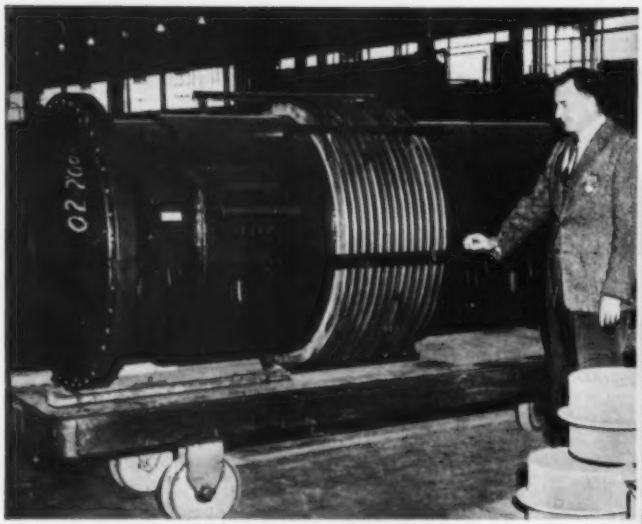

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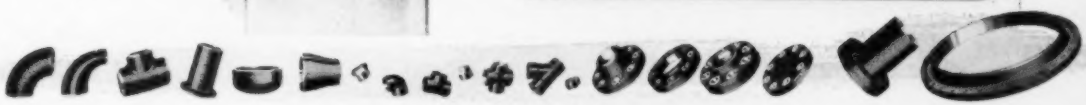

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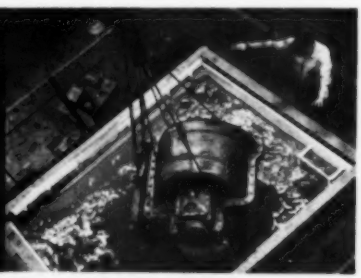

This leak test is one of many tough tests and inspections each Carrier Centrifugal Compressor must pass.

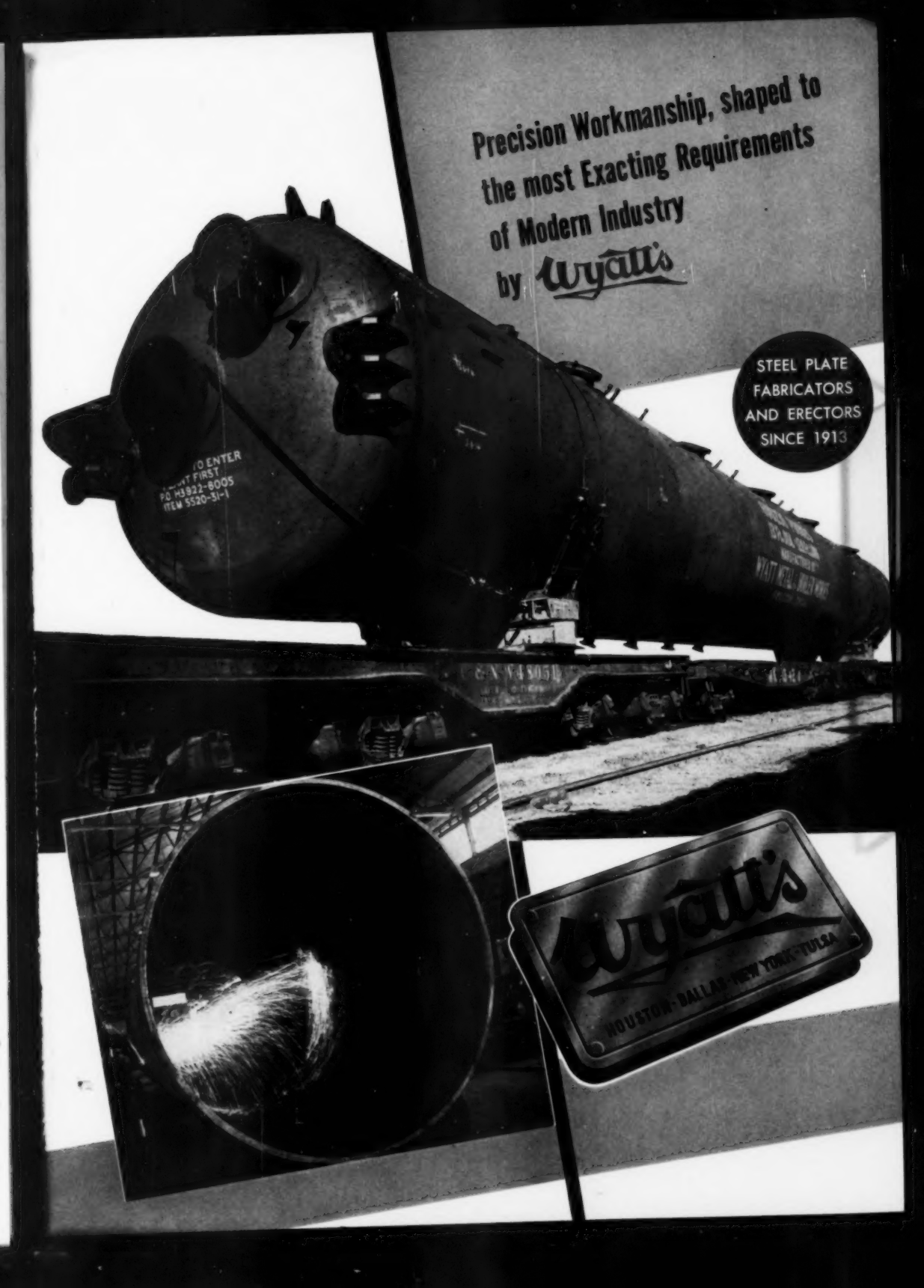
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Plate 814—McDonald Standard Swing Joint (Double). ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 6", 8", 10".

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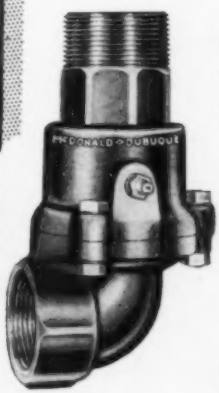

Plate 983 — McDonald Master Swing Joint (Single). A single ring is used for packing—replaceable, if required, in jiffy-quick time. 1½", 2", 2½", 3".

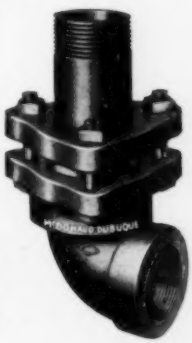

Plate 813 — McDonald Standard Swing Joint (Single). ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 6", 8", 10".